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ADVANCED MILITARY PAY SYSTEM CONCEPTS. EVALUATION OF OPPORTUNIT--ETC(U)
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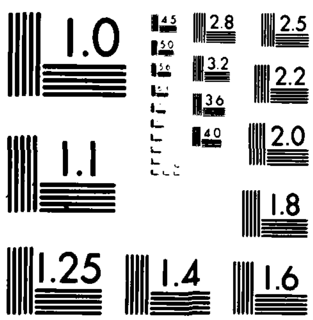

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OFFICE OF NAVAL RESEARCH

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ADVANCED MILITARY PAY SYSTEM CONCEPTS

EVALUATION OF OPPORTUNITIES THROUGH INFORMATION TECHNOLOGY

DITTBERNER ASSOCIATES, INC.

ADVANCED MILITARY PAY SYSTEM CONCEPTS

Evaluation of Opportunities
Through Information Technology

Contract Number: N00014-79-C-0686

Prepared for:
Mathematical and Information Sciences Division
Office of Naval Research

Prepared by:
Dittberner Associates, Inc.
Washington, D.C.
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BACKGROUND AND OBJECTIVES OF STUDY

A. INTRODUCTION

This research effort has dealt with the Navy system for managing pay and allowances for both active and retired Navy personnel. Its focus has been to understand the current system and its limitations, as well as to forecast technologically feasible alternative methods by which this pay system could be significantly improved and upgraded in the early 1990s, with primary emphasis on shipboard pay procedures.

1. Background

At present, the Navy system for managing pay and allowances for active and retired military personnel is administered at the Navy Finance Center (NAVFINCEN) in Cleveland, Ohio. System improvements are planned at the Navy Accounting and Finance Center (NAFC) in Crystal City, Virginia, as a part of the Financial Management Improvement Program (FMIP). In order to discharge its responsibilities under the FMIP, the NAFC needs to be aware of opportunities for military pay system improvements which could arise as the result of new technological developments. Thus, one of the major objectives of this current study effort was to de[illegible] those areas of technological advancement in the field of computers and communications which could have a significant impact on Navy shipboard pay systems.

2. Developmental Efforts in Progress

The current developmental efforts for military pay systems improvement are primarily oriented toward improved hardware and the use of electronic communications. These efforts seek to improve the present system operation through exploitation of past technological developments. By the mid-1980s, these efforts will be completed. The major on-going efforts of this nature include:

- PASS I--a physical consolidation of Navy field pay personnel and passenger transportation functions for all active duty shore activities into approximately 152 PASS offices
- PASS II--will provide automated support to these physically collocated field pay, personnel and passenger transportation functions with respect to active duty military personnel ashore. This plan is to provide support from small geographically-distributed computers to NARDAC's and selected PASS offices overseas, all of which are selected to minimize communications costs. On-line access would be provided to the computer locations to input personnel transactions and to provide inquiry capabilities into personnel files.
- PASS III--a management initiative to provide integration of the military pay and personnel functions into a single process for shore-based personnel.

As further system improvements in the 1990s are contemplated, the NAFC needs to consider the implications of recent and anticipated technological developments that may be significant not only for implementation of the military pay system, but also on its basic conceptual nature. However, the NAFC does not have the technological forecasting and assessment capability in-house. As a result, the import of recent and anticipated technological developments is not always appreciated, and the long range opportunities for military pay systems improvement are not always clear.

3. Problem Definition

NAFC lacks an assessment of the implications of recent and expected technological developments on the design and implementation of military pay systems in the 1990s. Such an assessment is necessary in order to ensure that NAFC does not miss major long range opportunities for system improvements, particularly those of a basic conceptual nature.

B. RESEARCH OBJECTIVES

The research objective of this study effort is to provide an investigation of military pay systems by a firm with expertise in the field of information technology. The investigation is oriented towards the implications of recent and expected technology applicable to shipboard Navy pay systems. Alternative pay system concepts and configurations are suggestd on the basis of these investigations.

The major research questions are:

- What recent and expected developments in information technology have implications for the Navy pay systems of the 1990s?
- What are the nature and significance of these implications?
- What are the consequent likely alternatives for military pay system design and implementation?

1. Study Area Exclusions

The required research was not meant to consider changes in the legislative characteristics of the military pay system. For example, the possibility that Congress may replace the present system of pay, allowances, and entitlements with a military salary structure need not be considered (unless, of course, technological developments are such that the possibility is unusually attractive).

The research requested was also defined to exclude a detailed economic analysis of alternative configurations of future military pay systems. Nor was there a need to provide a noneconomic basis for selecting one alternative over another. Only an orientation to the implications of technology was desired. The detail provided is sufficient to guide NAFC's senior analysts in planning and executing military pay system improvements.

2. Need for Verification of Planned Evolution of the Military Pay System

One of the implied objectives of this overall study effort was to examine the planned evolution of the Navy pay system within the context of a possible range of conceptual solutions made possible by modern and anticipated technological developments between now and 1990. Thus, a verification of this planned evolution was desired, or the highlighting of alternative system concepts which provide a redirection of this planned evolution as outlined previously.

C. DEFICIENCIES OF CURRENT SYSTEMS SUBSTANTIAL

The deficiencies of the current system can be tied directly to the problems of data reporting. The inaccuracy and untimeliness of reported data are largely the result of the methods currently used for reporting pay and personnel transactions. Typed, flat paper diary entries, and an optical character recognition (OCR) system utilizing multi-part forms are the primary vehicles for inputting data to the headquarters. These same systems are used today for reporting personnel information to the Bureau of Naval Personnel (BUPERS) and pay information to NAVFINCEN. The respective data bases at these sites, the Manpower Personnel Management Information System (MAPMIS) and the Joint Uniform Military Pay System (JUMPS) are inaccurate and out-of-date due to time delays in the U.S. Postal Service, data errors in the OCR systems, and the manually-prepared diary entries. At NAVFINCEN, approximately 9% of all transactions failed to update the appropriate master files, while at BUPERS, update error rates average 13% from OCR and diary entries.

All of these transactions and payment authorizations are transmitted through the U.S. Postal Service or its equivalent. Thus, initial submission times are measured in days, and transactions discovered to be in error experience an extended delay in processing due to necessary research and correction procedures.

1. Delays in Updating Excessive

At NAVFINCEN, an average of 13 days' delay occurs between the date that an event occurs in the field and the date that it is processed through the OCR scanner. Over half of the JUMPS entitlement input is scanned more than 14 days after the event being reported, and 17% is scanned more than 30 days after the event. Transactions containing data incompatible with that currently contained on the Master Pay Account (MPA) are rejected. Depending upon the nature of the correction procedure required, the average error life cycle is in the range of 3.5 to 27.5 days for an overall mean of 11.3 days to resolve the rejects and post the transaction to the MPA. It has been determined that 27% of all rejected transactions require field assistance for resolution.

These delays cause improper and nonsequential processing of events, affecting the accuracy of the MPA, the Leave and Earnings Statement (LES) used by the field disbursing offices to pay members, and the financial reports used by BUPERS to manage the Military Personnel, Navy (MPN) appropriation.

Pay and personnel data base errors, resulting from undiscovered transaction errors and late submission of data, cause erroneous reporting on individual members, Navy strength, pay entitlements and personnel-related expenditures. Erroneous reporting, in turn, has serious consequences in manpower and budgetary administration. Clearly, the current field reporting systems do not adequately meet even minimum requirements.

2. Precomputed Military Pay Amount "Overrides" Excessive

The current system pays Navy men and women twice a month, using data produced on an individual (LES) provided by NAVFINCEN. Because the average age of this data is 55 days at the time of payment, the field disbursing officer is required to manually override approximately 50% of the computed pay accounts in order to give the service members a correct paycheck. Submissions and mail delays of the activity-gain information may result in the LES being a month late or never arriving. Field officers must then manually compute pay amounts and request the missing LES from NAVFINCEN. Such requests for missing LESs cost an average of over $13,000 per month. A final impact of the untimely pay data is the fact that the Navy overpays about 20% of its separated members. It is estimated that uncollected separation overpayments cost the Navy approximately $6.1 million per year. Additionally, another $2 million annually is estimated to be lost through overpayments waive/remitted for active duty members.

Thus, it is evident that the deficiencies of the current system, and even of the system anticipated under PASS I, are substantial and require at least the automated support proposed under PASS II.

D. MODERNIZATION OF NAVY JUMPS

The Navy JUMPS was designed and implemented under OSD directive from 1966 to 1976 to improve the military pay system and the quality of financial reports of expenditures under the Miliary Pay Navy Appropriation management. JUMPS was a major departure from the old active duty pay system in which pay records were created and maintained manually by the local disbursing officer and reviewed each six months. These records are now created and maintained at NAVFINCEN on a random access disk file. A summary of the record in the form of an LES is sent monthly to the local disbursing officer for computing pay amounts and to provide each member with an up-to-date summary of his/her pay account. Data to update the MPA at the central site is submitted on machine-readable OCR documents through the U.S. Postal Service.

The combination of PASS II and Military Pay System Improvements Plan (MPSIP) will give the following capabilities to local disbursing and personnel offices:

- Local editing and validation of pay data before it is transmitted to the central site
- Rapid transmission of data from the field electronically to the central site and vice versa
- Verification that data transmitted to this central site has actually updated the master file, or that a corrected resubmission is required on an immediate basis
- Substantially reduced paper handling throughout the system
- On-line capability to access and correct input which cannot update the master file because the transaction is in error
- Daily update of the master file
- Daily computation of pay entitlements, forecasts, and twice monthly reports to be paid
- Automation of certain manual processing
- Improved financial reports to the MPN appropriation manager
- Capability to pay Navy members from the central site using electronic funds transfer

The result of implementing these two programs is anticipated to reduce the total turnaround time of pay entitlement data to less than the 12-day maximum lag allowed by GAO and to largely eliminate the current disbursing officer override policy, allowing payment directly from the LES either locally or from the central site.

MPSIP is scheduled for completion by 1984, but PASS II may not be completed until 1985.

As an added measure to provide more timely and accurate submission of pay entitlement data to the central site, the Navy is designing a CRT-oriented microprocessor system for telecommunications input of transaction data to the central site. It is anticipated that this system will be ready to begin implementation in late 1980.

Summary of PASS II Source Data System

In brief, the PASS Phase II source data system will be a distributed data processing system with subsets of the central pay and personnel data bases (MAPMIS and JUMPS) distributed on regional minicomputers (field host processors) located primarily in the NARDACs. The field host processors will be linked to the field headquarters host processor located in Washington, D.C. and Cleveland, Ohio by a packet switching network. The pay and personnel offices located in the PASS offices will have interactive access utilizing CRT terminal devices to the data bases residing in the field host processors. This source data system will provide PSA/PSD personnel with an interactive inquiry, source data collection, management information and payday support capability.

II
EXECUTIVE SUMMARY

A. SCOPE OF RESEARCH

This research effort by Dittberner Associates, Inc. was focused on the investigation of recent and expected developments in information technology which have significant implications for Navy shipboard military pay systems in the 1990s. It identifies the nature and significance of the implications of these developments, presents a range of alternative system concepts for shipboard military pay systems and, finally, compares these alternatives.

B. STATEMENT OF THE PROBLEM

The current pay system of the Navy has become inundated by a barrage of paper. For the most part, pay procedures are dependent upon constant surveillance and override of erroneous documents. Major improvements have been planned for the shore-based Navy military pay systems, but the shipboard systems are still largely archaic and do not serve Navy members well or efficiently.

To a large extent, the problems encountered in Navy shipboard pay result from the need to serve mobile personnel with low priorities for the use of currently available tactical and strategic communication links. The Navy relies on the U.S. Postal Service for pay transaction flow and adds to its own pay administration problems the inadequacies of the postal system. Typically, roughly 50% of all of the computed pay amounts on the LES must be "overridden" by the field DO and recomputed based on current status information. This gives rise to tremendous inefficiencies in shipboard disbursing office functions, removes effective management control of the MPN appropriation and serves to reduce morale among Navy members because of incorrect pay computations which must be brought to the attention of the DO for correction. Greater use of information technology in Navy pay systems would serve to alleviate dependence on this inherently congested system of paper handling.

While a wide range of improvement programs are already being planned by NAVFINCEN, the Center lacks the capability to assess the implications of recent and expected technological developments in the field of information technology on the design and implementation possibilities for advanced military pay systems in the 1990s. An assessment of these developments is necessary in order to ensure that NAFC does not miss major long range opportunities for system improvements, particularly those of a basic conceptual nature.

This report is intended to provide such an evaluation and interpretation of the conceptual opportunities likely to be made available by advanced information technology developments over the next decade.

C. RESEARCH TECHNIQUES EMPLOYED

Our project personnel visited two ships representing small and large scale pay disbursement actions. We also obtained information from a range of shore-based military pay facilities and NAVFINCEN to obtain an overview of the existing flow in the Navy military pay system, the limitations on system implementation concepts based on the environment, and the deficiencies of the existing system.

We then interviewed a broad cross-section of information technology research and development facilities of the major manufacturers in the field. With this background, we postulated likely developments and analyzed the implications of these developments on a range of alternative system concepts.

D. INFORMATION TECHNOLOGY DEVELOPMENTS SIGNIFICANT TO MILITARY PAY SYSTEMS

1. Component Developments

The trend in memory components is towards function integration on chips through increased chip density. Through the use of VLSI and LSI, chips or chip sets are becoming available which provide the capabilities of today's mainframe computers. This trend is expected to continue through the decade producing highly-capable machines with reduced space and weight requirements. As densities increase, costs will continue to decrease. Communications protocols currently controlled by software will also be a part of the trend towards LSI hardware/software function integration and increased chip density. We predict that this technology will continue to evolve for much of the remainder of this decade so as to reduce the cost of larger memory and logic arrays by 20% to 30% per year.

Another trend in memory component development is towards reduced power consumption. This permits inexpensive battery backup to reduce system downtime.

But, while the cost and size reductions of semiconductor memory and microprocessor capabilities are anticipated to double the capacity/processing throughput each two to three years over the next decade, the significance of these developments to shipboard military pay applications is extremely limited. Data processing systems for shipboard use, including visual display devices, will become smaller, more reliable and less expensive than in the early 1980s. The cost of such small business systems will largely be controlled by the cost of input/output devices and of mass (electromechanical) storage devices. These devices are likely to remain roughly constant in pricing over the next decade because of the significant labor content in such devices.

2. Software Developments

Computer software development is likely to encompass two trends: integration of software into system hardware and replacement of COBOL with a higher-level, portable language. The integration of software into hardware is a part of the overall increased chip density already discussed. This integration has, in turn, created a need for language portability between systems. This need is being answered through extensions of the PASCAL language and its derivatives.

Although COBOL is used extensively throughout the federal establishment, it is a mature language and is already being replaced, to some extent, by the DOD-developed ADA language.

Software development costs continue to escalate, and in general, the investment in programming for major applications exceeds the investment in hardware. This may not hold true in this case, if a relatively large fraction of the Navy's larger ships were to be equipped for shipboard payroll computation. We would anticipate that the cost of converting the current COBOL payroll program to the more appropriate PASCAL language for implementation on a shipboard minicomputer/microprocessor system would cost in the range of $3 million to $5 million. On the other hand, a shipboard military pay system in the 1990s could well cost less than $20,000 per copy which if implemented for 600 ships would give rise to a hardware cost in the range of $10 million to $12 million.

3. Key Computer Technology Advances

The distinction between dumb and intelligent terminals will disappear towards 1990 largely because of the trend towards chip integration. As the anticipated cost of memory components decreases, the need for low-cost terminals incapable of editing/processing will also decrease. Eventually all terminals will have some degree of intelligence, and hence will become capable of performing data processing functions.

The technology of CRT visual displays is mature and is not expected to see much change in the decade of the 1980s. The CRT display will remain dominant in the marketplace. Future development in this area is expected to produce displays with higher resolution and perhaps the use of color. Use of liquid crystal technology may become more widespread for one-line displays, but the short life span of this display precludes its large scale entry into the data processing environment. The cost of CRT displays will remain relatively stable throughout the decade but feature enhancements will be available irrespective of inflation.

The low size and cost of memory allows the realization by 1990 of a member's personal electronic pay record stored in electronic memory, looking much like a thick credit card or a thin pocket calculator. This device could store the entire MPR in machine readable form with suitable internal controls to prevent fraudulent changes in the record.

Mass memory storage will depend increasingly upon disks. The tape cassette technology which pioneered this field will be replaced by disk storage because of its random access capabilities. Removable media enable the compact storage of information files as well as the easy transferrence of the files point-to-point.

Advanced floppy disk devices or their equivalent, with low cost removable disk media will cover a range between 100,000 bytes and at least several hundred megabytes. The Winchester disk drive with non-removable media which can store up to 100 megabytes with improved access speed will become available for $2,500 per unit in the early 1990s.

Digital videodisc technology will provide memory capacity of up to 1,000 megabytes per side of a 10-inch video platter with one to two second average access time. This will provide a highly economical low access rate, high capacity file storage which, by 1985, will be available at a unit price of $1,500 or less. The blank discs which are written by Laser techniques will be available for less than $22 each. This may prove very attractive to NAVFINCEN for MPR storage.

4. Printer Technology Developments

The field of automated printer technology is not expected to produce great innovation. Current printer technologies of the line and page types are expected to continue their dominance in the field. The impact printers can provide both typeset-quality and data quality output. The low-end quality printers are suitable for point-of-sale terminals and data output, whereas the typeset-quality is reserved for word processing applications.

Non-impact printers based on ink jet or Laser-Xerographic technology are, at this point, incapable of capturing a large share of the printer market because of

the inherent disadvantages in these systems. Ink jet printers have an ink storage problem; Laser-Xerographic printers are still in limited production and are therefore expensive. They also share the need for extensive maintenance with the closely-related office copier.

While performance increases are anticipated in medium and low speed printers, little in the way of significant cost reduction is anticipated over the next decade. The major improvement anticipated is in devices capable of acting both as a facsimile receiver and as an output printer for alphanumeric information. Such printers will also be capable of acting as the printing portion of copying equipment.

In general, the rate of technological development in the computer field appears to be slowing down compared to the rate of progress over the past two decades. In part, technological development and application is now paced by software development, where critical manpower shortages have evolved particularly in the telecommunications software area. These are likely to persist for the next five years. Because of the drag produced by slow software developments, most hardware developments in the next decade will prove to be largely evolutionary with very few breakthroughs anticipated with the exception of videodisc. Electromechanical peripheral input/output devices are already being produced in high enough quantity that little in the way of further cost reductions can be anticipated, with the exception of the medium-speed Laser printer. Since this device is currently in very low production, a current price of $7,000 to $8,000 is likely to experience a 60% to 70% reduction to the $2,000 level by 1990.

5. OCR Technology Developments

The use of OCR equipment in preparing part of the Navy payroll has already brought to light some of the problems inherent in this technology. OCR documents are error-prone and require careful paper handling to be effective. OCR equipment will, in the future, however, be used in conjunction with facsimile transceivers capable of reading digitally-compressed information fields from forms and transmitting it to a centralized file storage location for recognition purposes. Facsimile transmission of typed information will, in any case, eliminate dependence on the U.S. Postal Service which, in itself, is the major delaying factor.

The ability to economically implement digital compression on facsimile images and the ability to control the basic scanning format to achieve higher page scanning speeds makes technically and economically feasible the use of facsimile for the transmission of transaction information from ship to shore facilities. This is particularly true if such facsimile transmission is combined with a character recognition processor which deals directly with the compressed facsimile image at the central receiving site, eliminating paper flow and handling since no paper copy is produced at the central site. The integration of text editing capabilities with format control of data fields in word processors/data terminals gives rise to the opportunity to use the same device aboard ship for personnel records, military pay transaction recording, and preparation of administrative messages.

6. Cash Dispensing Equipment

In 1990, a larger variety of cash dispensing equipment will be available. However, little basic improvement and/or cost reduction over the presently available units from IBM and NCR will be achievable. Proper handling of money bills, "foolproof" design, and the necessary security precautions against break-ins and loss of bills through malfunctioning equipment will require expensive mechanical parts. Two versions of this equipment are currently available: One for wall installation secured by a heavy steel outer shell, and another with lesser external protection for use in bank lobbies, etc. By 1990, many different modular configurations for special applications will be available. We expect cost reductions of only up to 20% to 25% in constant dollars between now and 1990 for this type of device.

7. Automated Cashier Terminal Developments

The decreasing cost of terminal equipment components will make individual terminals capable of recording debit accounts on-line to a central shipboard microprocessor facility increasingly attractive. Such terminals could be used shipboard to track members' purchases from ships' stores. On-line access would enable debit information from the point-of-sale terminal to be accurately reflected in members' pay.

Automated cashier terminals will be built in higher volume and through a combination of competition and modularization are likely to be reduced in hardware cost by 50% or more in 1990.

8. Key Telecommunications Advances

There is a clear trend towards all-digital switching and the integration of digital switching and transmission facilities in both the land-based network and satellite communications. Further, many countries are moving toward an integration of voice/data in their evolving digital networks.

Satellite facilities on a regional, national and international basis will continue to expand rapidly. Prior to 1990, coverage of all major oceans of the world by two or more commercial satellite systems is anticipated. Because of the higher frequencies of newer satellites and the use of scanning beam antennas, smaller antennas for shipboard satellite terminals can soon be employed. We believe that most larger Navy ships (approximately 600) could be equipped with commercial satellite-earth station facilities without interfering with tactical military hardware.

The use of TDMA techniques and the packetizing of data communications for transmission purposes will increase the efficiency of satellite data transmission. We anticipate (only) a roughly 50% reduction in the current costs for data transmission via commercial satellite systems prior to 1990.

Satellite communications costs are distance-insensitive, and we see no particular reason why such communications should not be directed to a highly centralized facility, or to one of several regional facilities for processing, rather than being sent necessarily to the nearest possible shore-based processing location.

E. NATURE AND SIGNIFICANCE OF TECHNOLOGICAL IMPLICATIONS

Clearly, small data processing systems with telecommunications capability and visual display devices for shipboard use will become smaller, more reliable and less expensive than in the late 1970s. However, because of the requirement for centralized financial control and fund management, and more particularly because of the requirement for the distribution of allotment checks or EFT distribution of funds to dependents of Navy members, the advantages of performing the actual pay computation aboard ship are not great from a systems viewpoint, except possibly under wartime conditions. This is in spite of the basic economy which could be achieved by performing such payroll calculations aboard ship.

Most importantly, there clearly will be alternatives available in the early 1990s which will remove the dependence of the Navy military pay system upon the U.S. Postal Service. The adoption of any one of the several techniques for transaction capture aboard ship, and subsequent communication to a land-based central site could be employed to eliminate the use of the mails.

F. SYSTEM ALTERNATIVES MADE POSSIBLE

The range of alternative system concepts considered to incorporate new technology include the following:

- CRT-based local transaction recording device aboard ship, still using the U.S. Postal Service, but with a local editing and verification capability prior to mailing of transactions
- CRT-visual display terminal providing shipboard format control and editing. Commercial satellite transmission of transactions to the central facility and transmission of the LES to the ship for printing
- Automation of payroll/cash dispensing/ships' stores' transactions with a shipboard minicomputer and multiple CRT keyboard terminals. This concept provides additional services to Navy members to reduce the requirement for cash at ships' stores and provide cash through automatic dispensing equipment using a Navy credit card
- Use of a digital facsimile transceiver aboard ship and a character recognition computer at NAVFINCEN employing commercial satellite facilities for the transmission in both directions
- Shipboard deployment of multiple microprocessor-based small business system capable of storing the MPRs of all personnel aboard, plus the ability to do complete pay computation and preparation of LES documents. Allotments would be issued for NAVFINCEN, but primary record maintenance authority would be aboard ship. Satellite transmission on a periodic basis of transactions and actual amount paid to NAVFINCEN to allow appropriation accounting and maintenance of essentially duplicated personnel records
- Use of a portable electronic pay record in a shirt-pocket-sized unit which includes an identification card and photograph of the member laminated into the device.

This assumes a small business system aboard ship and at each shore facility capable of accessing NAVFINCEN computers to obtain the necessary encryption keys to update the individual payroll record, as well as to report actual disbursements made and transactions affecting pay. Thus, each ship- and shore-based facility would have the capability of generating the correct amount of pay to be issued locally, and would have local access to all of the factors making up the current pay for inquiry by Navy members. Alternatively, a digital videodisc could be employed for the payroll record but this would be less viable for other add-on functions, such as activating an automated cash dispenser or for debit accounting of the ships' stores.

G. COMPARISON OF ALTERNATIVES

The alternatives outlined which do not eliminate the use of the U.S. Postal Service cannot compare favorably with those using some form of electronic transmission of transaction information from ship to shore facilities. However, both the facsimile transmission approach and the CRT data terminal approach appear highly viable and meet system objectives.

The use of digitally-compressed facsimile image transmission devices offers a uniquely flexible method of data input, but it may suffer an unacceptably high error rate. (This issue requires further study--no system of on-line character recognition from facsimile image data is yet known to exist.)

The following table provides a basic comparison of the six alternative system concepts evaluated against a restatement of the major goals/objectives for active duty military pay systems.

SUMMARY OF SYSTEM CONCEPT COMPARISON

Selected Goals/Objectives	A CRT Transaction Recording	B CRT Terminal	C CRT Terminal Cash Automation	D Digital Facsimile Central Recognition	E Shipboard Pay System	F Electronic Pay Record Shipboard Pay System
Reduce Overall Pay Manpower Requirement by 20% or More	L	H	H	H	H	H
Ease of Future Moderniza- tion	M	H	H	L	H	H
Accurate Timely Allotments	L	H	H	H	H	H
Reduce Postage Cost	L	H	H	H	H	H
Provide On-Line Inquiry	L	M	M	M	H	H
Adequate and Efficient Audit Trail	H	H	M	M	H	H
Useful Work Measurement Reports	M	M	M	L	H	H
Allotments Easily Changed	L	H	H	M	H	H
Accurate MPR Accounting	L	H	H	H	M	M
Reduce Shipboard Space Requirements	M	M	M	H	M	M
80% Improvement in Pay Accuracy	L	M	M	M	H	H
Reduce MPR Errors by 99%	L	M	M	L	M	H

H = High M = Medium L = Low

SUMMARY OF SYSTEM CONCEPT COMPARISON (Continued)

Selected Goals/Objectives	A CRT Transaction Recording	B CRT Terminal	C CRT Terminal Cash Automation	D Digital Facsimile Central Recognition	E Shipboard Pay System	F Electronic Pay Record Shipboard Pay System
Reduce Field Overrides to Less than 1%	L	M	M	M	H	H
Improved Member Service	L	M	H	M	H	H
Deny Criminal System Access	M	M	M	M	M	H
Improved Member Transfer Service	L	M	M	M	M	H
Boost Morale of Disbursing Staff	L	M	H	M	M	H
Low Annual Communications Costs	H	M	M	L	H	H
Low Capital Investment	H	H	L	M	M	L
Standardized System Among Services	M	H	H	L	L	L
Provide Edited Transaction Input	M	M	M	L	H	H
OVERALL RATING	L+	M+	M+	M	H-	H

H = High   M = Medium   L = Low

SUMMARY OF ADVANCED PRODUCT FORECAST
SINGLE UNIT OEM PRICES

Product	Performance		1980 Price Min	1980 Price Max	1990 Price Min	1990 Price Max
Printers, Matrix	Tractor Feed	1980: 200 cps 1990: 800 cps	1,500	2,000	1,200	1,800
Printers, Belt	300 to 600 lpm		4,000	10,000	2,000	3,000
Printers, Laser-Xerographic	6 pages per minute		9,000	18,000	2,500	4,500
8-inch Floppy Disk	w. Interface	1980: 1 Mbyte 1990: 3 to 5 Mbyte	600	1,200	400	600
8-inch Winchester, one surface	w. Interface	4 to 8 Mbyte	2,400	3,000	1,100	1,500
8-inch Winchester, multi-surface	w. Interface	100 Mbyte	NA	NA	3,000	4,500
Main Memory	Semiconductor	1 Mbyte	8,000	20,000	1,200	2,500
CRT Terminal	12", w. Keyboard 80 x 24 characters		900	1,200	600	900
Smart Terminal	w. Minifloppy	w/o. Printer	2,600	3,500	1,800	2,400
Small Business Computer	16/32 bit CPU	2 floppy; 1 Winchester 1 printer	15,000	20,000	7,000	11,000
Large OCR Readers	40 page/min		300,000	400,000	250,000	350,000
Automatic Teller Machines	with safe and controller		24,000	28,000	24,000	28,000
Fax Send/Receive	Automatic	Group I or II	4,500	8,000	2,500	4,000
Fax Send/Receive	Automatic	Group III	12,000	20,000	3,000	5,000

III

REVIEW OF CURRENT SHORE PROCEDURES

Shore installations vary widely in size from those with fewer personnel than a large ship to those with complements in the tens of thousands, such as the Norfolk and San Diego Naval Bases. Even with this great divergence in size, the payroll procedures used by all shore installations are largely standardized, varying primarily in the volumé of transactions and in the level of local automation.

A. TRANSACTION FLOW

The hub of the payroll function for all the Naval military members is NAVFINCEN. Daily, tens of thousands of transactions flow inward to this center from the 500 Disbursing Officers (DOs) on the various ships and shore installations around the world, as well as from the Navy Military Personnel Command (NMPC). Monthly, hundreds of thousands of transactions and checks flow outward from the center. Practically all of these transactions are sent or received via the U.S. Postal Service.

1. Forms

Transactions effecting changes in the member's net pay are transmitted on 21 payroll and 7 personnel forms (see Appendix E). One form is a transmittal letter, which mandates that every transmission must include a minimum of two sheets of paper. All the forms are standardized, and the information is entered onto them with a typewriter using a special OCR type font and a specially inked carbon ribbon.

2. Transmission

Whereas the Army and Air Force rely almost exclusively on the military AUTODIN network for transmission of the transactions affecting their payrolls, the Navy uses the U.S. Postal Service almost exclusively for its transmissions of payroll transactions.

The AUTODIN network was established as a landline non-voice network. Initially, the Navy was unable to develop a system based on these landlines since so many DOs were on the seas. Therefore, the Navy developed its JUMPS pay system to the exclusion of AUTODIN. It is even now not a heavy user of this network for pay applications, primarily because of the physical equipment constraints on AUTODIN I.

These physical constraints are the limited transmission capability into the AUTODIN station in Cleveland and limitations on administrative data transmission directly from ships in and out of the network. The AUTODIN network consists of a number of major switches in the continental United States and several foreign countries. These switches are predominantly IBM 370-195 computers. All of these major switching centers now have the capability of transmitting via cable or satellite (usually commercial satellites), at a guaranteed 56000 Baud rate.

These major switches serve a number of tributaries or terminals, each with varying levels of transmission capability. The AUTODIN terminal in Cleveland is connected to a major switch in Syracuse, New York (Hancock Field), and the transmission rate into Cleveland is only 1200 Baud. Because of this relatively low data rate, transmissions into NAVFINCEN are slow. This low rate level can be increased upon demonstration of a need for a higher level. When the transmission level (line count) into and out of the NAVFINCEN terminal reaches 65% or more of the total capabilities of that route, COMNAVTELCOM could be requested to provide an increase, usually a doubling of the transmission speed.

In order to keep its communications facilities from becoming overly congested inbound, NAVFINCEN is slowly bringing stations onto the AUTODIN network. Presently, there are six small shore stations, all in foreign countries, which transmit a part of their payroll transactions directly to NAVFINCEN via the AUTODIN network.

The DOs in all other installations must use the U.S. Postal Service for the transmission of their payroll-related transactions. The number of transactions and size of transmission issued by each DO varies from day to day depending on both the size of the base and type of activities. However, the average daily volume of transactions received at NAVFINCEN approaches 70,000.

3. NAVFINCEN Storage of Transactions

Until recently, NAVFINCEN updated the Master Military Pay Account (MMPA) by entering, twice weekly, the transactions received from the field. Transferring the transactions received on the OCR documents to the more than 18,000 magnetic tapes on which the master files are stored requires a significant level of manual effort. The documents must be removed from the envelopes or packages, straightened where necessary, and fed into the optical scanning readers. Additional manual efforts are required when one of the OCR documents is not properly centered and becomes jammed upon entering the reader. Further, major manual effort levels are required for processing documents when the OCR reader fails to find a complete and readable transaction.

Storage of the master files on magnetic tapes does not permit a truely random access search. In order to improve the efficiency of the internal file update and review processes, two significant initiatives have been started. The first of these is ECCO (On-line Error Correction and Control). ECCO has been designed to substantially reduce the time it takes to correct pay account errors. The first requirement of ECCO is the shifting of the MMPA to disks to permit immediate inquiry from remote terminals. This effort was started in November 1979 when 40 IBM Model 3350 disks, with a capacity of 317 million bytes each, were installed. There are presently 43 remote inquiry cathode ray tube (CRT) terminals installed (all at NAVFINCEN) with an additional 200 terminals on order.

The second of the near-term initiatives is a team concept of operations. Because of the delays in a mail-based system, NAVFINCEN made the decision that all corrections will be made in Cleveland, and only those errors which cannot be resolved there will be referred to the field. Presently, special groups are maintained for transaction processing for allotments, payrolls, allowances, separations, W-2, claims examination and customer service, etc. Under the team concept, specialists from each of these groups will be assembled into a team responsible for a set number of accounts. This team concept will result in a noticeable reduction in the error corrections time as team members will be able to communicate more easily and effectively.

4. NAVFINCEN Processing and Transmissions

The NAVFINCEN computer center operates 24 hours per day, using three shifts. The majority of the data processing workload is in the periodic file updates and in error corrections. Until recently, error corrections could take weeks due to the sequential processing required by the tape-based system. This file is now on magnetic disks. The heaviest demands for processing fall at the end of the month when the LESs are produced. About 80 hours of time of the dual 370/158 computer system in concurrent processing and more than 50 hours for printing is required to produce the LESs and those checks sent out from the Finance Center.

Approximately one-half of the 525,000 monthly LESs are printed in Cleveland and mailed to the field DOs. The other half are recorded on magnetic tapes which are mailed to the DOs in the larger installations equipped with computers. In addition to the LESs, NAVFINCEN transmits back to the field those documents with errors in received transactions which could not be corrected in Cleveland.

NAVFINCEN produces no active duty paychecks. These are produced by the field DOs. The checks printed at NAVFINCEN are those which are issued once a month only and include allotment payments (about 300,000 per month), retired pay (about 325,000 per month including about 100,000 accounts on EFT), and reserve drill pay (about 86,000 per month). With the exception of the 100,000 EFT payments to retirees, all the foregoing payments are made by mail. By using the "composite-check" procedure to individual banks for many of the allotments, a significant reduction is realized in the number of checks that must be printed.

B. PAYLINE PROCEDURES

In making the actual semi-monthly payrolls at shore installations, paylines are not used. All military personnel at shore installations are paid by check. Cash is used only when a special pay is necessary, generally when one of the members is required to travel or has requested that the accumulation of all his back pay be paid to him on separation, or in an emergency. In these instances, cash will be issued, if requested, up to $1,000. All special pay over $1,000 is made by check.

1. Alternative Methods of Pay

As with all units in the Navy, each member assigned to a shore installation has three pay options:

- Sent by mail directly to his checking or savings institution--termed "PDQ" pay
- Sent by mail to his home or other private address--this option is generally discouraged in favor of PDQ pay
- Delivered to him personally at his duty station

2. Large Shore Installations

At or near the end of each month, the DOs of the larger shore installations receive from NAVFINCEN magnetic tapes which contain the information necessary to print the LESs of the members stationed at that installation. The LESs are printed in DO sequence and verified for accuracy. From these LESs, adjusted when necessary, the paychecks are printed. The commanders of the various Unit Identification Codes (UICs) pick up the checks of their personnel from the DO and distribute them to the individual members. The LESs are distributed with the paychecks due the 15th of the month to eliminate an extra distribution. These LESs show the individual member the amount he should have received on the 30th of the previous month, the forecasted amount due him when he receives his LES and on the 30th of that month.

3. Small Shore Installations

For those smaller shore installations which do not have the necessary computer output printing capabilities, individual LESs are printed by NAVFINCEN and mailed to the DO. After correcting any LESs which are in error, the DO prints the paychecks, and they and the LESs are delivered to the individual members by the UIC commanders. Some of the smaller bases print their paychecks through the use of punched card tabulating computers. This is the shipboard JUMPS (SJUMPS) system used aboard the larger ships. At the few bases which are too small to have a card printer or access to one, the paychecks are prepared manually on a typewriter.

4. Check Cashing at Shore Installations

The Disbursing Office of each base is a part of Personnel Support Activity (PSA) of that base, as is the Personnel Office. These PSAs do not cash the members' paychecks on those bases where there is a Navy Exchange or an office of a commercial bank. On those small bases where these facilities do not exist, the PSA will make arrangements to cash the members' checks.

C. FISCAL CONTROLS

Procedures are established with JUMPS to provide controls for account balancing at the end of each pay period. All DOs and clerks are specifically designated and charged with this responsibility. Fiscal controls in JUMPS are integrated into the overall system procedures as follows.

1. Payday Processing System

The current Naval pay system is designed to support the local maintenance of Navy pay accounts. The system begins with the receipt by the disbursing office of the LES tape or printed copies from NAVFINCEN. This information is to be received at the disbursing office not later than the 5th calendar day of each month via mail.

The LES provides information for processing the two paydays during the month--the 15th and 30th. All payments are to be made by check (either individual or composite). A composited check is one deposited in one bank for several members who are customers of that bank.

The primary feature of the Payday Processing System (PPS) under JUMPS is to provide for the automated reconciliation of the LES produced by NAVFINCEN with the data contained in the local Pay Master File (PMF). This reconciliation procedure will isolate accounts requiring manual attention. PPS performs the following functions:

- Printing the LES tape from NAVFINCEN in the sequence used for member distribution and in the Personal Financial Record sequence
- Maintaining the local PMF which contains data required to process the payroll
- Reconciling the LES tape with the PMF to update it and to isolate accounts containing discrepancies

- Completing the payday processing, including the preparation of checks, money list and money list tapes
- Producing special reports at the discretion of the disbursing office. (Reports used by the disbursing office are sometimes prepared manually.)

The system organization includes four processing steps, as follows:

- Match-Compare Processing: The tape from NAVFINCEN is compared to the PMF. Accounts containing discrepancies are identified and printed on an Exception Report. (The major portion of this is done manually since accounts are known to be out of sync with the LES in advance of payday.) After the tape has been compared to the PMF, the LESs are printed in duplicate, bursted and computer sorted in member and in pay clerk (DK) order. Each DK handles a specifically assigned group of personnel, varying in numbers as follows:
  - 550-600 permanent
  - 325-350 students
  - 200-225 disciplinary cases

  Each DK has the responsibility of manually comparing the new LESs to the prior ones as a part of the match-compare process.
- Update Processing: The PMF is updated by initiation of the DK to reflect changes in the member pay accounts. (Continual manual override must be done until changes show up in the LES.) Changes can originate from the Exception Report, JUMPS documents submitted by local personnel offices or changes requested by members.

Changes may be input into the system on a Master Change Document (MCD) or by a Pay Master Card (PMC). The MCD is an OCR document. The PMC can be a mark-sense card, or if mark-sense equipment is not available, a keypunch card.

The change information is posted to the PMF (tape), and a summary is provided on the Edit and Balance Report for each DK.

- <u>Payday Processing</u>: When the DO determines the PMF tape reflects payments due members for the current payday, the payroll is processed. The paychecks are printed and punched (for later sorting). The check distribution and listings, check register and money lists are produced.

  A Final Balance Listing is prepared to assist in payroll balancing. The money list tape is produced for submission to NAVFINCEN.

  After each payday, a Payday Adjustment Report is produced. This prepares the PMF for the succeeding payday.
- <u>Cancelled Check Processing</u>: An optional automated Cancelled Check Processing routine is available. This routine will produce a mechanized Schedule of Cancelled Checks (SF 1098).

In JUMPS, there is provision for override in the event the LES does not accurately reflect the actual amount due. The system allows the input of the corrected information during the Update Process.

The "Will Pay" portion of the file contains the LES forecasted amount or the override amount submitted. It will automatically be adjusted after each

payday, so that the correct amount for the succeeding payday is entered. The forecasted LES or the PPS override field totals are always based on the total of the Will Pay fields for all records on the PMF.

2. Control Totals and Balancing

Certain control totals are integrated into the design of each process of the PPS to ensure the balancing of payrolls. These include:

- Match-Compare Process: The amounts forecasted for the payday of the 15th on the LES tape will be totaled. This total is adjusted to provide a Beginning Payroll Total by deleting amounts for members who are being maintained on the PMF in an extract suspense status. The Beginning Payroll Total is adjusted to provide a New Payroll Total by adding or subtracting (override) amounts due members because of entitlement changes, members who are not on the LES tape, or are on the tape but deleted from the PMF (unmatched locals). This New Payroll Total will always be the Beginning Payroll Total against which adjustments are made during the first update process.

  When match-compare processing has been completed, each DK is provided with an Exception Report which will furnish New Payroll Totals for their respective roll, and the DO is provided with a summary of the payroll totals by pay group. These totals reflect the amount which would be expended should the payroll be processed without further updating of the PMF.

- Update Process: The New Payroll Total created from the Match-Compare process is used as the Beginning Payroll Total for updating by the DOs. The New Payroll Total arrived at during the last update prior to the payday processing will be the total of the payroll when it is processed.
- Payday Process: The payroll total will equal the total of the Will Pay amounts on the PMF following the latest update. The total of the mid-month payday will thus become the Beginning Payroll Total for the end-month payday on the Adjustment Report. This total is adjusted due to override amounts, changing the amounts in Will Pay for the 30th payday and providing a new payroll total for each DK to use in the next update process. A summary of the New Payroll Totals is provided to the DO.

  The New Payroll Total generated during the update process following the 30th payday will not be used for future updates unless the LES tape is not received from NAVFINCEN in time for the normal match-compare process.

Also indicated as of major importance is the proper scheduling of operations throughout the month to ensure that all processing is completed on a timely basis to meet the needs of the disbursing office. Unless proper scheduling is maintained, all steps in processing cannot be accomplished to provide the members with the amount of pay current due.

D. EQUIPMENT EMPLOYED

Production of a payroll of the magnitude of the U.S. Navy requires a considerable amount of electronic data processing and other sophisticated equipment. Essentially the Naval payroll computer system has been tape-based, although improvements and efficiencies are being phased in. The master files have only recently been transferred to magnetic disks.

1. NAVFINCEN Data Processing Equipment

In order to meet the requirements of central site maintenance of the Navy payrolls, a large scale ADP system was installed in Cleveland. This tape-based, batch processing system installed with mail-based input could not maintain up-to-date pay accounts. Recognizing this deficiency, the Navy is now replacing its tape storage facilities with random access disk storage coupled with CRT terminals for local inquiry. This conversion is necessarily a slow process, requiring training of personnel and frequent test checks to ensure that essential records are not destroyed or altered.

The majority of the equipment used by NAVFINCEN is installed in its computer complex in Bratenahl, Ohio, a suburb of Cleveland. In this center are two IBM 370/158 computers coupled as a uniprocessor, two CDC 3300 computer systems, eight CDC 915 OCR scanners, a Mitron telecommunications terminal, a tape library containing some 20,000 reels of magnetic tape, two Model 3211 printers, each capable of printing 2,000 lines per minute, two Model 2501 card readers, each capable of reading 1,000 cards per minute, 32 tape drives, 40 recently installed IBM 3350 disk drives and some of the more than 200 CRT visual display terminals planned and on order.

The master files and transactions processed by the OCRs are stored on the 20,000 reels of tape. All of the MMPA data has now been transferred to the disks, and random access to an individual member's account is possible. But the updating function is still done through sequential processing. It is anticipated that full disk storage and retrieval will replace the tape MPRs by the end of 1980.

In addition to the equipment in the Bratenahl annex, some equipment is located in the Federal Office Building in downtown Cleveland (NAVFINCEN headquarters). The equipment in this location consists of an IBM 360/30 computer, an IBM 1401 computer (used primarily for standby), two Xerox 1200 non-impact printers and other peripheral equipment such as check/bond inserters, bursters and deleavers. The majority of the CRT remote terminals are also in this building.

2. Field Installations' Data Processing Equipment

Following the computation of the members' pay and the issuance of the LESs at the center, certain equipment is required at the field installations to complete the issuance of pay. The amount and types of equipment in the field varies with the size and type of installation. At those installations which receive the LES tapes from NAVFINCEN, electronic data processing equipment is necessary. A Burroughs model 3500 computer is installed at the larger shore installations and a UNIVAC U-1500 (SNAP I) computer is installed aboard large (automated) ships. These computers facilitate verification of the accuracy of the NAVFINCEN LES tapes and permit more rapid error detection, correction, and check preparation.

In addition to these computers, key punchers, card readers, reproducers, interpreters, collators and printers are required at the field installations, as well as such support equipment as decollators, forms bursters and check signing machines. These latter three items are not always available at all the larger installations.

As the size of the units decreases, so does the amount of equipment. A small ship (destroyer size or smaller) has only an OCR typewriter for transaction document preparation.

E. CONTROL AND MANAGEMENT REPORTS

A series of controls and management reports has been developed within the Navy financial functions to enable the Navy to present its budgets in support of Congressional appropriations, as well as to account to Congress, through the GAO, for its expenditures. The reporting procedures extend from the field DOs through NAVFINCEN.

The Chief of Naval Personnel is responsible for budgeting and accounting for the MPN appropriation. NAVFINCEN, in turn, is responsible for supplying that office with the information needed to perform those functions. Based on the information and reports provided by the DOs, the MPAs of the active duty members are kept up-to-date. Based on these MPAs, monthly financial reports are produced by NAVFINCEN to support the MPN in active duty military personnel budgetary matters, in making analyses of costs of legislative proposals and in developing backup data for support of witnesses appearing before Congress relative to defense of funds required for military personnel programs.

1. Controls and Deficiencies

One of the most important controls in the payroll function is the correction of errors in the individual MPAs. While each separate error may not be of significance in the overall budgeting procedure, the magnitude of them hampers the efforts of the MPN appropriations manager. The basic five reports provided by NAVFINCEN are produced from the MMPA maintained in Cleveland. In order to provide financial accountability and control of the program, subsidiary accounts are established and maintained. This procedure enables reviews and analysis of expenditures to be made to ensure that MPN funds are being expended for the purpose appropriated in accordance with the Congressional restraints placed on the appropriation.

In spite of the controls and subsidiary accounting, the reports produced by NAVFINCEN require extensive manual computations to obtain the statistical data necessary for budgeting and accounting purposes; for example, the DOs

charge all pay and allowances to the fiscal year in which payments are made. These expenditures must be adjusted to the fiscal year in which the entitlement was earned to meet the budgetary appropriations requirements. Criticism has been received from GAO and the Navy Audit Service because of the amount of manual computations and adjustments required to put the reports in the necessary format.

2. Description of Reports

The current financial reports produced by NAVFINCEN through JUMPS are monthly reports limited by a fixed structure and are not sufficiently flexible to support the MPN appropriations manager's requirements. These reports are produced from pay and allowances information extracted from the MPAs. They are produced at the end of the month, verified by NAVFINCEN and forwarded to the office of the Chief of Naval Personnel prior to the 13th of the month following the report month. The five reports are:

- The Accrued Entitlement Detailed Classification Code Report. This is a budget statistics report which identifies, by fiscal year, the entitlements of pay and allowances included in members' MPAs during the report month. The purpose of this report is to provide the appropriations manager data to measure budget performance, adjust the budget, and to forecast budget requirements for subsequent fiscal years.
- The Accrued Entitlement Summary Report. This is a summary of the information contained in the above report at budget activity and subactivitiy levels. It is furnished to support maintenance of the appropriation accounting ledgers and to provide the appropriations manager with the basis to record actual accrued entitlements as obligations, or accounts payable, in the appropriation accounting ledger.

- The Accounts Payable Report. This report identifies the monthly entitlements as accounts payable for net pay, deductions from pay and related government contributions. The accounts payable are identified by functional account numbers and provide a greater detail of information than is available in the appropriation accounting ledgers and registers.
- The Net Pay Payments Posted Report. This report is provided to inform the appropriations manager of the net payments posted to members' MPAs for the month with cumulative month and fiscal year totals. The report enables the appropriations manager to identify differences in the amount of net pay recorded in the appropriation ledgers and the net pay payments posted in members' MPAs.
- The Unpaid/Overpaid Analysis Report for Net Pay. This report was developed to furnish the appropriations manager gross and net unpaid/overpaid balances for net pay reflected in the members' pay accounts.

3. Solutions for Report Inadequacies

We believe that a major reason for the inadequacies of these financial reports lies in the large percentage of field overrides of the precomputed LES Will Pay amount, occasioned by the slow flow of transactions affecting the pay amount through the U.S. Postal Service. Other methods of transaction flow must be implemented before significantly improved financial reports can realistically be generated.

F. OVERALL FLOW

A tremendous volume of transactions (two million per month) is required to maintain the Navy payroll on a current basis because of the continual changes in the pay and entitlements due the members. Since the Navy transmits its payroll transactions almost exclusively by the U.S. Postal Service, the number of transmissions between the Finance Center and the field is more than three times greater for the Navy than for the Army or Air Force, both of whom transmit their transactions via the military AUTODIN network. The following is a summary of military pay transaction statistics.

	Navy	Army	Air Force
Active Duty Members including Reserve and National Guard	611,000	1,284,000	709,000
Average Monthly Transactions	2,000,000	1,200,000	792,000
Average Monthly Transactions Per Active Duty Member	3.3	0.9	1.1

We do not mean to imply by these ratios that a total conversion of the Navy's payroll transactions to the AUTODIN network would automatically reduce the transactions to half or less of the present level. However, a conversion to some electronic means of communications would result in a significant reduction in the number of transactions and in the time now required for LES override to be reflected in financial reports.

Most importantly, the timely flow of transactions from the field to NAVFINCEN would soon eliminate the need to report <u>all</u> pay amounts individually each pay period and permit exception reporting of pay amounts differing from the LES forecast only.

IV

REVIEW OF CURRENT SHIPBOARD PROCEDURES

As a basis for this discussion, we reviewed the procedure manuals for JUMPS and SJUMPS. Additionally, the Dittberner Associates' project team visited two ships at Norfolk, Virginia--the U.S.S PIEDMONT and the U.S.S. BRISCOE. The PIEDMONT is a destroyer tender with a crew of some 900 and the BRISCOE is a destroyer with 260 members.

The PIEDMONT uses SJUMPS, and when in port, uses AUTODIN. The BRISCOE is a smaller ship utilizing a manual form of JUMPS. This visit provided us with the opportunity to discuss the pay systems with actual users. We were briefed on the procedures used, as well as the problems associated with implementing and operating the system. Further, we examined the pay system from the point of view of a large ship and a smaller ship to have some comparison of the impact on each level of automation employed.

In this chapter, we review shipboard procedures as they now exist. We cover the transaction flow aboard and as it interfaces with NAVFINCEN. Our discussion includes the payline and fiscal control procedures used by the disbursing office to effect member's pay. The physical security procedures aboard ship are discussed in terms of the information revealed during our visit. Lastly, we discuss the overall flow and indicate the existent problems which must be compensated for in the development and design of new system concepts incorporating advanced technological innovation.

A. TRANSACTION FLOW

The essential transactional document affecting individual crew member's pay is the LES. It is the basis for each member's twice monthly pay, as well as a record of leave earned and taken.

1. Basis of JUMPS

The JUMPS program provides for automated data transactions which may be stored on magnetic tape or punched cards. This information is prepared for submission to a centralized financial center for processing.

Under JUMPS, NAVFINCEN maintains an MPA for each active duty Navy member. The MPA is the official pay account for all active members and contains all pay and personnel data necessary for the computation of pay and leave. Supporting personnel data is provided by the Navy Military Personnel Command (NMPC) with updating data submitted directly by field disbursing/administrative personnel.

Naval personnel aboard ship or at a shore facility are paid twice monthly. An LES is prepared for each active member on the 23rd of the month and is due at the ship by the 5th of each month for processing. The LES shows the payment due on the 30th of the month and forecasts the payments due on the 15th and 30th of the month in which the LES is received at the ship.

2. Receipt of LESs

In both cases of ships with JUMPS or SJUMPS, the LESs are sent by mail from Cleveland prior to the month-end payday. The disbursing office aboard ship posts in the various divisions a list of each member's pay to be received on the next payday, for review by affected members. This is done from one to four days prior to payday, depending on the mail facilities and time available to the DK.

From the time the pay list is posted until payday, members may contact the DK concerning discrepancies in the amount to be paid. This can include new members who may not find their name on the pay list. Questions of discrepancies may occur up to the time the members receive the actual pay. It is also part of the DK's responsibility to check the amount on each LES manually prior to payments to isolate errors which require correction prior to payday.

In the case of any type of discrepancy--primarily overpayment or underpayment--the disbursing office may override the current or forecasted pay computed on the LES. Overrides or annotations, including computation of pay, are done manually by the DK and annotated on the member's LES.

The LES is received in duplicate with one copy to be presented to the member on payday. Annotations on the LES are made only on the disbursing office's copy and are retained in the member's semi-permanent file.

Annotated changes to the LES must be input into the system to be picked up by NAVFINCEN and to be corrected on the member's records. These changes are also necessary to the final balancing of the disbursing office's account. These changes are recorded on OCR documents for submission to NAVFINCEN.

3. Recording of Override Annotations

We were told that the override procedures on both ships were used 50% to 75% for each member's pay each month. Any pay change requires the override procedures to be used in order for the member to receive the correct pay due. Further, override procedures, particularly on smaller ships without access to an on-board computer, generated considerable manual work in addition to the amount required to simply keep the system moving.

For a ship with an on-board computer, changes in the LES-computed pay could be input into the system prior to check printing via punch cards. For a ship having the more manual JUMPS system, a check must be manually cut to make up the difference in payment, if necessary, or a manual notation on the LES made for a member paid in cash.

4. Updating Information

The override function creates further requirements for the updating of the Military Pay File (MPF) in NAVFINCEN. A further complication of the file

update is the issuance of the 30th pay amount and the forecasted computation for the 15th and 30th of the succeeding month. This inherently generates problems for at least 31 days, if not for the following 46 days, if there is a problem in a member's LES pay amount. In fact, however, the time lag is frequently anywhere from two to sixteen months! The following Exhibit IV-1 provides a timing chart for JUMPS payments for members.

5. Check Printing Versus Cash

Depending on the ship facilities available, the checks for each member may be printed with data processing equipment or with a typewriter. The DO on small ships may choose to have the members paid in cash. Amounts are paid in even dollars to avoid the need to carry an excessive amount of silver change--particularly when a ship goes to sea.

In the case of the ship with SJUMPS, the disbursing office had access to an automatic check printer but did not have access to a check signer. Thus, approximately 1,500 paychecks for each payday had to be signed by hand.

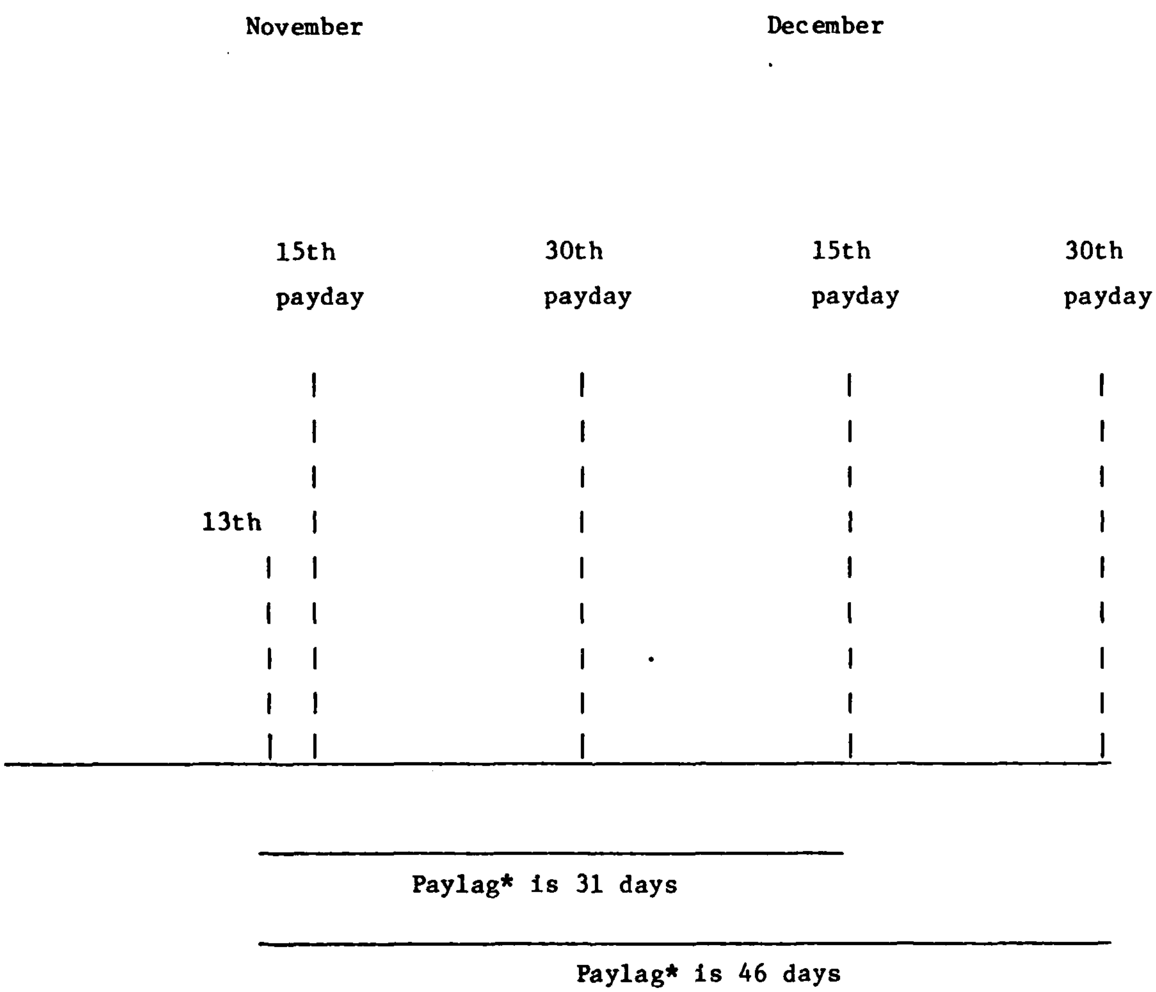
The smaller ship we visited did not have the ability to produce checks automatically and paid its members in cash. The ship did have facilities to pay members by check if there were discrepancies in the amount of pay which required adjustment and for issuing payments of travel vouchers.

It was a policy of the smaller ship to offer a combination of check or cash payment for officers but for not enlisted personnel. This was to keep the amount of additional work to a minimum and provide a little more service to the officers. All enlisted personnel were paid in cash only.

6. Provision of Foreign Currency

The provision of foreign currency is an extra service provided to members when in a foreign port. The disbursing office makes arrangements to purchase foreign currency locally (usually through the U.S. Embassy or Consulate) and provide exchange conversions for all or part of a member's pay. The overall

CURRENT NAVY JUMPS



*Events occurring during these time frames will not be reflected on the succeeding 15th and 30th paycheck.

EXHIBIT IV-1

function of payment in foreign ports of local currency and/or conversion is incidental to this survey and is only mentioned as a factor involved in shipboard pay.

7. Transmission

The transmission of information between ships and the Finance Center is primarily by mail. In the case of small ships with no computer support, the LESs and all other documents are always received and transmitted by mail, even at sea.

For largers ship utilizing SJUMPS, the pay systems are automated and thus have some additional facilities. In port, the information may be transmitted to the Finance Center via the AUTODIN network. These facilities are limited so all ships are not able to use AUTODIN, therefore, mail is also used. Additionally, the older computers used on shipboard are seven-track tape versus the nine-track tape capability of the Finance Center computer. Thus, there is a limitation on the amount/type of information which can be transmitted, since the seven-track tape cannot accommodate some of the information formats required by the system and requires a conversion step prior to transmission over the AUTODIN system.

When a large ship is at sea, documentation must be transmitted via mail. The LESs are prepared in Cleveland, generally on the 23rd of the month, and mailed to the ship in duplicate for the 30th payday and the forecasted period.

In the case of a small ship with manual procedures, Naval Form No. 3056 is also transmitted by mail. This form lists each crew member by name, social security number, amount to be paid and a blank line for the member's signature, used to verify that the cash pay was received.

Since both size ships incur continuous problems with the timeliness and accuracy of the information contained on the LES, additional transmissions of the daily diary are required throughout the month. These transactions include

annotations to the LES and changes in allotments, as well as other information relating to the member's status. If the ship is preparing to go to sea for an extended period, the level of transactions (largely allotment changes) increases sharply, as also happens upon return. While at sea, the required level of transactions and, hence transmissions, is reduced to a modest level.

Both of the ships' personnel indicated the transmission of daily diary information to the NMPC was a particularly problematic area. The delay in getting the information to the Finance Center to update the LESs tended to increase the number of overrides required to effect a correct payday for members. This in turn radically increased the workload, especially for the small ships with a manual system.

Improvements for Transaction Flow

Shipboard personnel felt the time-lag associated with the flow of information causes considerable problems in effectively performing their duties. As a result, more than one-half of the LESs received from the Finance Center must be overridden each payday. Anywhere from two to sixteen months elapsed before the LES was updated correctly. The workload was self-perpetuating because of the continued propagation of errors and the requirements for overriding the LES. As a result, it is clear the transmission of information permitting a turn-around time of pay entitlement data of less than a 12-day maximum is absolutely essential to providing any meaningful benefits of automation to the ship's DO.

B. PAYLINE PROCEDURES

The LESs, when received, are verified by the disbursing office for accuracy. This verification procedure results primarily from experience, since problems are expected with a large percentage of the LESs because changes in the amount paid in the previous period would not yet be reflected in the new pay amount.

A ship with automation support would submit the corrected LES for keypunching, and the corrected amounts would be printed on the member's check. Payroll information is posted one to three days in advance of payday so that any problems can be brought to the attention to the disbursing office prior to payday.

Navy Form 3056, provided to the smaller ships with manual pay procedures, is posted three to five days prior to payday. This posting allows the crew members sufficient time to bring errors to the attention of the disbursing office.

1. Method of Payment

There are variations between the automated and manual systems for payment. Ships with automation have the capability to print checks from the computerized information contained in the LES tape. Thus, all members are paid by check. One member of each division on the ship is designated to pick up and sign for the checks. The checks are then handed out to the crew members within the division. At a designated time, the disbursing office forms check-cashing teams to cash the members' checks. Cash is issued for the entire amount of the check only. Checks are in even dollar amounts to eliminate the need for handling coins. On the average, 85% to 90% of all payroll checks are cashed each payday.

The smaller ships without automation pay principally in cash. Without the ability to print checks, the time and effort required to manually type, then cash checks for the entire crew is prohibitive. Checks, or a combination of check and cash, are provided to officers, chiefs and first class petty officers. Any crew member encountering problems with a payday may also be issued a check if required.

2. Pay Procedures at Sea

When a ship is away from the home port, the disbursing office provides additional services for crew members. The normal pay procedures are generally followed, however, an additional payline may be established to provide foreign currency in exchange for dollars.

If the ship spends an extended time at sea, the disbursing office may allow members to carry pay on the books. This is more often the case in the smaller ships with fewer personnel where it entails less bookkeeping.

3. Pay Disbursing

On the larger ships, after distributing the checks through the divisions, the disbursing office sets up check cashing teams of two members each. The use of two persons is for verification of the amount of cash disbursed. Paylines are established for portions of the alphabet for the purpose of distributing personnel among the check cashing teams.

Although the number of personnel involved in cashing checks varies depending on the number available and the size of the crew, four to six is the average number used.

After the member's check is cashed, he or she has the option to purchase a money order at the shipboard post office. The money order may be deposited in a checking account by mail or held until a future time when the member may need additional cash. The money order protects the cash from pilferage.

Personal checks not exceeding $500 are cashed by the disbursing office of the larger ships during specified hours each workday. In the case of smaller ships, checks are cashed only while the ship is away from the home port.

C. FISCAL CONTROLS

The extent to which the disbursing office aboard ship can accomplish the elements of processing involved in fiscal controls is dependent on the level of automation. At least a portion of the transaction must be accomplished at the local level (ship) in any case.

The fiscal controls integrated into the PPS processing have previously been outlined in Chapter III, Section C. In the following sections, the applicability of the processes are related to ships with either SJUMPS or more manual procedures.

1. SJUMPS Fiscal Controls

For ships having computer support, the majority of the fiscal controls can be implemented aboard. Since the shipboard computers are usually outdated and use keypunch equipment which is often not working properly, not all of the capabilities of SJUMPS can be implemented.

Despite the extent to which SJUMPS allows for automation, it has not solved the problem of the time lag in updating the member's LES. As a result, 50% to 75% of the LESs have to be overridden on each payday. This impact is extended because the status of accounts which are not updated after four to six weeks must be manually checked. Further, experience indicates that verification of the LES is done prior to posting, since numerous changes are anticipated.

Computers used on ships are more limited in function than those used at shore facilities. Ship computers do not, for example, have the capability to receive the LES on magnetic tape. Changes may be made on the amount paid to a crew member via override of the system by keypunching the correct pay amount. However, until Cleveland makes the correction and it appears on the LES mailed to the ship, such overrides must be performed each payday. The ship's disbursing office must submit the following monthly reports:

- o Pay and entitlement transactions
- o Total financial returns
- o Record of checks issued (to the U.S. Treasury)

Additionally several times a month, the disbursing office submits to Cleveland various types of transactions which must be input to the member's personnel file and LES. These changes must be reconciled with the central and local files. The information that appears on the LES is essentially the only verification that a change has occurred. No provisions for initial edit and change are accommodated in this system.

2. Ships Without SJUMPS

For smaller ships without computer support, the major portion of fiscal controls are manual. Theoretically, with fewer members the workload should also be less. Further, smaller ships are accommodated by not paying the entire crew by check. Calculators and typewriters are the extent of automation.

The LESs are printed in Cleveland and forwarded by mail to the ship along with the money list. The disbursing office reviews the LESs for accuracy and posts the money list for the crew's information. The crew receives cash and must sign the money list to verify the pay was received. The disbursing office must type all checks by hand. The payline always has at least two clerks per line to serve as verifiers for each other in the disbursing of cash. As in an automated system, the DO has the responsibility of balancing out at the end of each payday. The balancing of accounts includes all accounts handled by the office, including travel claims and other procedures. The balancing and control is performed manually.

Summary

Overall, the ships have standard fiscal controls required for payroll accounting. The larger ships have computer support for balancing accounts via on-board systems. Smaller ships, however, must rely on the Cleveland facility to provide the basis for automated support via production of the LES and subsequent updates. Local override capability is available for both sizes of ships.

D. PHYSICAL SECURITY PROCEDURES

The limitations of space and weight have considerable influence on the type and amount of physical security which can be utilized.

1. Disbursing Office

The physical security of the disbursing office depends on the interior arrangement of the ship. Generally, the office itself can be locked when unoccupied. Where feasible, there is an alarm system (silent, if possible) that is connected to the always-guarded quarterdeck of the ship. Thus, if there were an intruder in the disbursing office, the alarm would be activated and personnel dispatched to the area. The extent of security is relative to the physical space available, age of the ship, location of disbursing office, etc.

2. Cash and Record Security

Safes are provided aboard ship for storage of cash and check stock. Although it is desirable to store both personnel and cash records in the safe, space limitations, particularly on ships with a crew over a thousand, may preclude this. Thus, in some cases only the cash and possibly the check stock can be stored in the safe.

In case of abandonment of the ship, the most important item to be removed is the record of cash and cash disbursements rather than the actual cash since the records are essential to the reconstruction of the transactions.

E. OVERALL FLOW

The transaction flow between U.S. Navy ships and NAVFINCEN can be mapped in considerable detail via flow charts for paper and computer programs. We provide a simplified approach in this section.

1. Ships with SJUMPS

The ships' transactions vary slightly between when they are in port and when they are at sea. The payroll system is primarily mail-based, and major transactions between the ship and the central facility are essentially two-way. Transactions flowing between a ship in port and Cleveland via AUTODIN are communicated to a regional switching node(s) within AUTODIN enroute to Cleveland.

When at sea, mail must travel to an intermediate point and then to the ship. In fact, however, the flow amounts to a two-way transaction.

2. Smaller Ships

The flow of transactions between the ship and the Finance Center is via U.S. Postal Service. Most documents are produced on an OCR typewriter and mailed to Cleveland to the Personnel and/or the Finance Center. Each OCR document is then input to the system master file. Most of the document flow is from the ships to the central facility.

Overall transaction flow is charted in Exhibit IV-2. Our review of the shipboard procedures associated with the Navy payroll system indicates that this flow of information is the heart of the system and the area which requires the major effort. The complexity and uniqueness of the Navy's requirement to serve mobile ships is well recognized by the Dittberner Associates' project team. It is with this awareness that we develop recommended system concepts in this survey.

OVERALL NAVAL PAY SYSTEM TRANSACTION FLOW

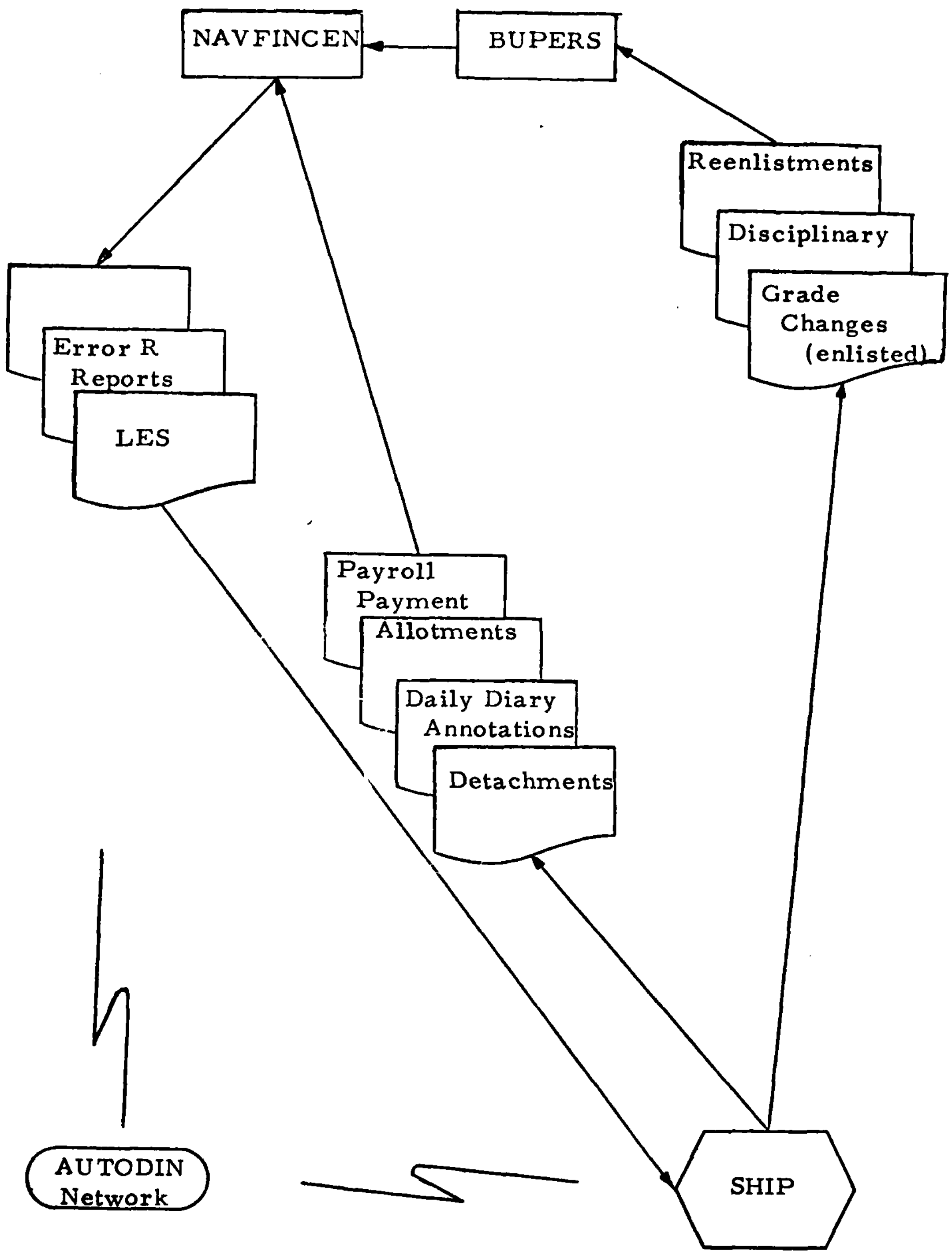


EXHIBIT IV-2

Dittberner Associates Inc.

V

EVALUATION OF CURRENT SYSTEMS

The current Naval payroll systems are continually changing in an effort to improve accuracy and reliability. The systems for active duty pay at shore installations and aboard ships are quite similar, except for the restrictions inherent in shipboard actions.

A. ADVANTAGES OF CURRENT SHORE-BASED SYSTEMS

The extensive use of DKs at shore installations gives the members the distinct advantage of personalized service in payroll mattters. Each DK is assigned a specified number of Naval members who contact him or her, initially, for any changes or problems in pay. The clerk maintains a Personal Financial Record for each of the members assigned to him/her, in which the past LESs of the member are filed. In addition, copies of all change transactions affecting that member are maintained in the file until the effect of the change appears on the LES. From these documents, the DK is able to override the member's LES, when necessary, to ensure the member gets the correct amount of pay.

The policy of having the UIC commanders deliver the paychecks to the members in their command assures the interest of that commander in getting the pay to individual members promptly. For those members who have elected to have their paychecks sent to their homes or banks, the closeness of the paying office ensures that changes can be made in a timely manner.

The policy of maintaining the payroll records in Cleveland and conducting the payroll computations there reduces the possibility that errors may result from using a multitude of computation points. This centralized storage has also enabled a reduction in the personnel required in each disbursing office.

B. DISADVANTAGES OF CURRENT SHORE-BASED SYSTEMS

The biggest disadvantage of the current shore-based systems is the high percentage of errors occurring in the members' LESs. A certain number of errors are to be expected in a payroll system the size of the Navy's. But the errors in the Navy system are magnified by the slowness of the U.S. Postal Service in delivering the transactions to Cleveland from the field DOs. Further, a significant number of errors occur in the members' MPAs because of mistakes in the preparation, transmission and reading of the OCR documents by which changes and corrections to the MPAs are made.

C. ADVANTAGES OF CURRENT SHIPBOARD SYSTEMS

The current shipboard payroll procedures have been established to get the member's correct pay to him or her on time. Each member has the opportunity to have all or part of his/her pay deposited or paid elsewhere through the Navy's allotment procedures, thus assuring secure handling of funds.

By providing Post Offices aboard ships, each member can secure the portion of pay not desired in cash through the purchase of postal money orders. The Post Office facilities aboard ships have aided in decreasing the temptations to members to engage in blackmarket or other illegal activities. Purchases of abnormal amounts of money orders alert the command and investigations are made in order to safeguard each member's pay.

D. DISADVANTAGES OF CURRENT SHIPBOARD SYSTEMS

The delays encountered in shore-based systems become major drawbacks for shipboard systems. For ships, the dependence on the U.S. Postal Service for transmissions is an added disadvantage, particularly when the ship is at sea. The changes and error corrections from deployed ships frequently are not reflected on the members' LESs for three or four months. This delay is especially crucial when a member fails or forgets to adjust allotments when the ship is deployed.

Another disadvantage aboard ships is the difficulty the individual members have in protecting their pay from pilferage. The disbursing office also has a security concern in ensuring that the cash maintained on board is not stolen.

Using paylines to distribute pay aboard ships is time consuming not only for the DO's staff, but also for the individual members. This cumbersome disbursement procedure is aggravated on board the larger ships where the pay is made by check. Here, the member must wait in one line to get the check, in another to cash it, and in a third to purchase a postal money order to protect the cash.

E. OVERALL EVALUATION OF CURRENT SYSTEMS

The Navy's policy of ensuring that each of its members is paid in full the total amount due on each payday is commendable but expensive. Current payroll systems are labor intensive. A minimum of two persons is required to handle the paying of members. Continued dependence on the U.S. Postal Service for transmission of the processing information to NAVFINCEN guarantees a continuation of the high error rate in the production of the payrolls. Until this error level can be brought under control, the Navy cannot transfer any of its active duty members to EFT.

VI

ARMY, NAVY AND AIR FORCE MILITARY PAY PROCEDURE COMPARISON

We contacted members of the Army and Air Force Finance sections to obtain information on the evolutions of their respective pay systems for comparative system approaches. Both of these systems are based on JUMPS established by the military in 1974 and implemented by the Navy in 1977. Since all three services based their military pay procedures on the JUMPS mandates, they have many similarities.

A. MILITARY FINANCE CENTERS

Under JUMPS, each service established a central finance center in which the basic payroll and leave data of each military member is maintained.

NAVFINCEN in Cleveland maintains and updates information on some 933,000 members (active duty, reserve and retired). The basic MPR for each member is stored on magnetic tapes. Recently, 40 Model 3350 disks were installed to provide local high speed random access to the pay and leave records. NAVFINCEN uses dual IBM 370/158 computers.

The Army Finance and Accounting Center is located at Fort Benjamin Harris in Indianapolis, Indiana. Here, the Army maintains and updates information on some 1,707,000 members (active duty, reserve, national guard, and retired). The MPRs of the members are stored on disks permitting random access of each basic record and subsequent updates. The Army has just installed a UNIVAC 1100/82 computer in its finance center.

The Air Force Accounting and Finance Center is in Denver, Colorado. Basic information on some 1,144,000 members (active duty, reserves, national guard and retired) is stored and updated on random access disks. The Air Force uses an IBM 370/168 computer coupled with an IBM 360/65.

B. FIELD ORGANIZATIONS AND FIELD TRANSACTION FLOWS

Basic pay and leave information on each military member is maintained at the three service finance centers. Updates and adjustments to this information are sent to the centers from the respective Military Personnel Commands of each service an. :om field finance officers. Most of the information received is from the field finance officers.

1. Navy

The field finance officers in the Navy carry the designation of Disbursing Officer (DO). There are 500 DOs serving the various Navy military units, submitting approximately two million transactions per month to Cleveland to update the members' MPRs. Nearly all these transactions are sent via the U.S. Postal Service.

The Naval JUMPS system uses 20 forms to update its members' MPRs. Of these forms, 10 have been placed on the NAVFINCEN computer data base and can be received in OCR format from shore stations. Only 5 of the 20 forms can be received in automated format for the SJUMPS system. The Navy has six small shore installations and four ships on a trial basis connected to the military AUTODIN network for payroll and leave purposes. The six shore installations send ten forms (JUMPS) via AUTODIN and the four ships send five forms (SJUMPS). All other transactions are sent by mail.

There are presently 80 ships on the SJUMPS system. Most (approximately 76) of these ships submit the information for the five automated forms by magnetic tape or punched cards to Cleveland by mail. All of the other transactions are OCR-typed documents. Personnel at NAFVINCEN hope to have all 20 forms placed in automated format in the computer data base by the summer of 1980.

2. Army

The field finance officers in the Army are designated Finance Officers (FOs). There are 120 FOs serving the various units, generally of division or corps size.

The average number of monthly transactions submitted by these FOs is 1.2 million. Except for a few isolated bases, all the transactions are transmitted via the AUTODIN network. The field information required to update the members' MPRs is currently recorded entirely on punched cards which are electronically transferred by the AUTODIN network through card reader terminals at the base communication centers. The transmissions are received at the Indianapolis AUTODIN terminal and stored until they can be entered into the members' MPRs (on-line).

3. Air Force

The field finance officers of the Air Force are designated Accounting and Finance Officers (AFOs). There are 113 AFOs serving the various Air Force bases around the world. These AFOs submit an average of 792,000 monthly transactions to the Denver Finance Center. Except for a few isolated bases, all of the transactions are transmitted via the military AUTODIN network. Each AFO has access to a Burroughs 3500 computer established at the base. In making the daily transmissions to the finance center, the AFO submits the transactions to a preliminary audit at the base computer and then transmits from the computer over the AUTODIN network. As the data are entered into the member's MPR, a detailed comparative edit is performed. If a message is in error, it is routed back to the AFO via the network for correction. If rejections require that an answer be returned to Denver, it must be made within 48 hours. About 15,000 transactions are rejects sent back to the field. The preliminary edit at the base computer significantly reduces the number of monthly transactions between the field and the finance center.

The Air Force is the only service branch currently using CRT data terminals in the field. Nearly 45% of the Air Force bases are equipped with "read only" CRTs used to access the MPR files. This access is via the commercial telephone network rather than AUTODIN. Each CRT was installed only after the AFO involved had demonstrated that its use would result in a verifiable reduction in personnel requirements. The Air Force is presently studying the advantages of using CRTs to input transactions into the central computer and eliminate the use of the base Burroughs 3500 computer. Although these studies are not completed, the study group is confident that this capability will provide significant additional manpower savings.

C. LEAVE AND EARNINGS STATEMENT (LES)

The LESs of the three services are all based on the JUMPS system and contain basically identical information, varying only in format and presentation. Each LES identifies the military member by name, social security number and military unit designation. Each LES shows the base pay of the member accompanied by a listing of all entitlements, allotments and deductions with the net pay due. In addition, the amount of earned unused leave is indicated. The LESs are based on a member's MPR maintained at the respective financial centers and issued monthly. Each finance center must update its MPRs to reflect changes in rank or rating, assignments to or from hazardous duty posts or positions, missing in action, killed in action, AWOL and disciplinary cases, and all other changes affecting the pay amount, such as longevity, and the use and accrual of leave. LESs are not prepared for retired members.

1. Format of the LESs

The format of the LESs of the Army and Air Force are basically the same but vary from the format used by the Navy. In the former two services, the allowances and allotments are listed in parallel vertical columns and totaled to arrive at the net pay for the month. This net pay is then broken into two nearly equal amounts to show the net pay due the 15th and 30th of each month. Each of these services gives it members the option of receiving one monthly paycheck.

The LESs issued by the Navy differs from those of the other two services in that the allowances and allocations are printed in predesignated boxes on the form. The Navy LES shows the amount of net pay due the military member on the 30th of the month and forecasted amounts due that member on the 15th and 30th of the succeeding month. In most instances the Navy LES is delivered to the member with the check of the amount forecasted as due on the 15th, making the printing of the amount due on the 30th of the preceding month meaningless.

The payroll amounts shown on the LESs of both the Army and the Air Force are for the 15th of the month and the 30th of that month only. In the case of those officers electing to receive one paycheck per month, the LES shows only that month's net amount due.

2. Method of Issuing LES

For all three services, the basic information contained on the final printed LES is generated in the respective finance center. The method for actual issuance of the LES varies slightly among the services.

Navy

The Navy distributes the members' LESs in two ways. For large shore bases, magnetic tapes are sent through the U.S. Postal Service to the DO of each such base. The LESs are then printed at the base. For all other Naval installations, including ships, the LESs are printed at NAVFINCEN and sent to the DO via the U.S. Postal Service. All the LESs are distributed to the military personnel by hand at the duty station. Although the LESs are to be printed on the 23rd of each month, there is no established regulation as to the date of delivery to the military member. In a number of instances, as mentioned above, the LES printed on the 23rd of one month has been delivered to the member with the paycheck of the 15th of the succeeding month.

Army

All of the Army LESs are printed in Indianapolis and sent by mail to the field FO. They are then distributed by hand to the members through the unit commanders. The closing date for including changes in the Army LESs is the 16th of the month. They are sent from Indianapolis so that the military member has the LES at the end of the month covering the succeeding month.

Air Force

On the 20th and 21st of each month, the Air Force finance center makes up and mails 113 magnetic tapes to the field AFOs with instructions to print and deliver the LESs to the members a minimum of one day before the payday of the 30th. LESs are printed in the field at the base computers on a self-mailer form and mailed so as to reach the payee at home on the date due.

3. Number of LESs Retained by Field Payroll Officer

The number of LESs that each field payroll officer must keep in the member's Personal Finance Record (PFR) varies among the three services.

Navy

A minimum of six LESs are maintained in each PFR file by the field DOs, although most DOs keep twelve LESs. This enables the DO to override the LES when the indicated amount of pay is in error.

Army

Initially, the Army required that the LESs be retained by the field FOs for six months. They went to 12 months and then ascertained that 18-month retention would adequately serve their personnel. The general procedure of the Army is not to override the payroll amounts shown on the LESs. The Army attitude is that if an error is made in the payroll this month, it will be corrected next month. Only about 2% or 3% of the members receive a check drawn by their field FOs to represent late pay changes, and then only in the case of an emergency.

Air Force

The LESs of the Air Force members, like those of the Navy and Army, are printed in duplicate. The Air Force AFO, however, is not required to keep a file of the member's LESs and generally throws them away. Like the Army system, changes in an Air Force member's pay are corrected on the LES of the succeeding month. A check or cash is issued to an Air Force member for a pay change only in the case of an emergency. Therefore, there is infrequent need for overriding the LES.

D. TYPES OF PAY

The Finance Centers of the three services must handle five types of military pay. The approximate break-out of the classes of payrolls at the end of fiscal year 1978 are as follows:

Personnel	Navy	Army	Air Force
Active Duty Pay	525,000	752,000	562,000
Reserves (Paid Status)	86,000	188,000	54,000
National Guard (Paid Status)	0	344,000	93,000
Retired	322,000	423,000	435,000
Totals	933,000	1,707,000	1,144,000

In addition, each finance center pays the allotments elected by the military members.

1. Active Duty Pay

Navy

The Navy meets its active duty payroll by check or by cash. The Navy member may receive the check or have it deposited in a bank or savings institution. With the exception of small ships' (destroyer class and under) personnel, all Navy members are paid by check. On smaller ships, Navy members are paid in cash. Only the officers and upper-level non-commissioned officers on these small ships can receive a paycheck, if they request it, because of a shortage of personnel available to type the checks.

Army and Air Force

All Army and Air Force pay is by check. Cash is issued only in cases of emergency.

2. Reserves (Paid Status)

The procedure for handling the payroll of reservists in a paid status is basically the same as that for active duty members, i.e., a combination of cash and check for small units in the Navy and all other payments by check.

3. National Guard (Paid Status)

The Army and Air Force pay their National Guard members entirely by check, generally mailed to the member's home or banking facility.

4. Retired Pay

The payrolls for retired members of all three services are done by check or by EFT.

5. Allotments

Allotment payments for members of each of the three services are made by their respective finance centers. There are three basic methods of making these payments, all of which use the U.S. Postal Service for transmittal of the check. For payments made to someone in the military member's family, the check is mailed directly to that person. If the allotment is to the member's financial institution (bank, savings account, etc.), and it is the only payment going to that organization, a direct deposit check is mailed. When a number of payments go to the same financial organization, the Composite Check Program is used. A list of the name, account number and net deposit of each individual member is submitted to the financial organization with one check covering the total of all the deposits submitted by members to that organization.

E. ELECTRONIC FUNDS TRANSFER

Electronic Funds Transfers include any transfer or transmission of money by electronic means. The organization responsible for converting federal recurring payments to EFT is the Operations Planning and Research staff of the U.S. Treasury Fiscal Service. Presently, the military payroll systems which may be paid by EFT are Navy, Army and Air Force retired payroll and the active duty payrolls of both the Air Force and the Marine Corps. The Navy is not contemplating converting its active duty payroll to EFT at present because of the high error rate (48%) in its LESs.

None of the individual military allotment payments are on EFT. An EFT payment is made only to a financial organization (commercial bank, savings bank or Federal credit union). The majority of allotment payments are third-party transactions, i.e., insurance premiums, mortgage and/or car payments, etc., and therefore are not accommodated in the software of the EFT system. Until such time as the Treasury Department revises the software, allotment payments will not be permitted on the EFT network.

VII

GOALS/OBJECTIVES FOR ADVANCED SYSTEM CONCEPTS

Before detailing the advanced systems concepts to be evaluated in this study effort, the Dittberner Associates' project team, in conjunction with our subcontractor, Mathtech, documented the perceived goals and objectives for advanced military pay systems. The importance of defining these goals and objectives is to meet the specific needs of the U.S. Navy which are unique and complex in relation to the other services and private industry. The results of the project teams' efforts are outlined below.

Many of the current deficiencies and the objectives for short- and long-term accomplishments are already well established by NAVFINCEN. The project team has further defined these goals/objectives for the development of alternative advanced systems concepts.

A. SHORT-TERM GOALS/OBJECTIVES

Short-term solutions to the Navy's current problems with timeliness and efficiency must be designed to improve current procedures, while moving in the direction of an advanced system solution and without requiring a complete replacement of the current system and equipment.

The short term goals and objectives perceived are:

GENERAL

- o Implement modern data base management techniques to improve efficiency of system and reduce manual manpower requirements
- o Initiate integrated system development through plan which allows ease of update and modernization. Implies software-based system

- o Implement update system capable of reflecting current status of member's pay and pay records
- o Reduce the number of facilities requiring advanced pay system equipment through centralization or regionalization
- o Reduce payment distribution costs and accompanying postage costs by at least 20%
- o Reduce operating costs of paying services and input and output of information
- o Provide on-line inquiry system for Naval Reserve pay system and improve financial reporting
- o Establish edited transaction input control capability
- o Provide central site, and to a lesser extent the local facilities, with sufficient audit trail and balancing capabilities
- o Provide useful and accurate work measurement and financial management reports
- o Implement random access of stored information
- o Integrate disbursing and accounting functions to input financial data to central accounting and finance office and utilize telecommunications networks to reduce paper-flow
- o Improve computer support system equipment aboard ship to current state-of-the-art to reduce space requirements
- o Use EFTs where possible to reduce check production at NAVFINCEN

TRANSACTIONS

- o Reduce manual changes on LES in order to reduce work-load on field personnel
- o Standardize format of information to allow transfer of skeletal master records between various data bases

- Develop computation method to provide accurate (to 80%) and timely payroll data
- Improve payment data accuracy to reduce account balance discrepancies by 85%
- Reduce field override of LES data to less than 1%
- Reduce override on separation accounts to less than 2%
- Shorten life cycle of an error to two weeks
- Reduce field personnel man-hours involved in error follow-up
- Reduce the number of NAVFINCEN billets required for error correction by 10%
- Reduce the cost of manual effort required to maintain off-line accounts by 80%
- Improve the accuracy of off-line accounts for integration to a level comparable with on-line system accounts
- Reduce by 99% the number of documents processed to correct errors
- Reduce requirement for clerical effort to reformat existing data for use by appropriations manager
- Provide field capability to perform initial edits and validation updating before transmission of pay information to central site
- Provide on-line access to correct erroneous or incomplete input which cannot update the master file
- Provide MPR update verification
- Provide capability in field to make error corrections and changes on member's records for transmission to central facility. LES adjustments to leave records to be performed after-the-fact to alleviate another level of adjustment
- Reduce paper handling
- Use AUTODIN II network for rapid exchange of information affecting Naval pay accounts and financial reports

COST OF LIVING AND HOUSING ALLOWANCES

- Reduce by 99% the number of cost of living and housing allowance rate changes prepared by the field and submitted to the central site
- Ensure the accuracy of the cost of living and housing allowances to 99% when entered on the MPA and LES
- Increase financial report accuracy to 99% involving cost of living and housing entitlements
- Ensure entry of the most current cost of living and housing allowance rate changes within five days after change is authorized

RESERVE FORCES

- Implement local capability for reserve drill sites to enter information for reserve pay into system
- Reduce operating and postage costs of reservist pay service

RETIRED

- Reduce payment distribution cost for retiree's pay by 15% in use of manpower
- Reduce costs for payment distribution cost for retirees by reducing postage
- Provide cost effective and responsive system for establishing, maintaining and paying retiree's accounts

B. LONG-TERM GOALS/OBJECTIVES

The long-term goals and objectives of the Naval pay system are more general in nature than the short-term objectives. Over the long term, the percentage of accuracy, efficiency and cost savings should be higher than over the short term. We will outline below the long term objectives and goals perceived for the Naval pay system.

- Improve service to members which has been reduced by the current system rather than enhanced
- Improve the management capabilities of the overall system for financial and data base information
- Reduce continual backlog of errors and corrections to 1%
- Speed up the transaction time for input and output between the central site and the local field facilities to less than one day
- Reduce by 80% the manual effort required within the pay system
- Reduce the requirement for any manual override of the system except in the most urgent cases
- Provide capability for input of changes into the system within 24 hours
- Provide capability for accessing centralized information on member's pay and personnel records on a limited basis
- Provide proper system security against access for criminal purposes and to meet requirements of the Privacy Act
- Provide increased service to transferring member and to his/her family
- Automate the travel voucher system, now done manually, to reduce unpaid overtime for service personnel and to avoid paid overtime for civilian personnel

- Provide computation assistance for travel vouchers through increased accuracy in preparing forms on a terminal
- Provide capability for DOs to reduce time spent in manual operation of pay system and therefore, provide more job satisfaction
- Reduce errors and provide better pay service to boost morale throughout the service

C. LEGAL REQUIREMENTS FOR NAVY PAY SYSTEM

Some of the legal restrictions on how the payroll system should operate are contained in the GAO Policy and Procedures Manual for the Guidance of Federal Agencies. In Title 6, Chapter 3, Section 15.1, it is indicated that the lag in paying individuals shall not be excess of twelve days.

The Bureau of the Budget regulations have specific guidelines for the Army and Air Force. Title 37, Section 1005 indicates that "prompt payment requires that members of the Army and Air Force will not experience arrears of more than two months, unless there is good reason." For some reason, these BOB regulations do not specifically cover the Navy. The same GAO procedures as referenced above indicate that "payment should be made by check unless compelling reasons exist why this cannot be done. If cash is necessary, the individual must sign a receipt or payroll form (3055 or 3056). If the check is used, the member's endorsement would be sufficient to fulfill the requirement."

In the case of the use of an EFT, the authorization form filed with the bank would be sufficient to act as a voucher for receipt of payment. Hence, these are some of the legal requirements imposed on the Navy pay system which must be considered in formulating new concepts.

D. SPECIFIC SYSTEM OBJECTIVES--SHIPBOARD

The following is a restatement of additional goals and objectives more specifically related to the shipboard pay system.

- Save weight and personnel aboard ship by reducing the number of administrative personnel per 100 duty-oriented members. There is now approximately one DK per 500 personnel aboard ship and one PN per 100 personnel.
- Reduce the administrative support costs with adequate protection and adequate service to shipboard members
- Standardize military pay systems among the services
- Decentralize pay records access to give better service to members
- Maximize use of automated EFT system
- Reduce dependency of the pay system on the U.S. Postal Service
- Reduce drastically the number of error transactions
- Reduce drastically the over- and underpayments to members resulting from inaccurate records
- Increase the flexibility of the system to deal with variable bonus levels
- Make the reserve pay system more compatible with the active pay system to avoid record/transaction conversion requirements

VIII

INFORMATION TECHNOLOGY TRENDS--COMPUTERS

The purpose of this chapter is to identify those trends in information technology (excluding telecommunications, which is covered in the following chapter) which may have a substantial impact on the opportunity for system improvements or entirely new and improved system concepts for shipboard military pay systems in the early 1990s.

Thus, our objective here is primarily to identify and provide rough cost estimates for new technology capable of performing within the shipboard environment for Navy military pay systems only--NOT a complete overview of the field. However, a large segment of information technology is covered; the part not detailed here relates to major data processing installations and purely voice-related telecommunications developments.

A. LSI AND VLSI CIRCUITRY

LSI technology, which was widely regarded as suitable only for applications requiring moderate operating needs, has developed into the dominant technology for implementation of main operating memory, microprocessor circuitry of all kinds, and many specialized interface and telecommunications circuits of increasing complexity. While LSI technology has advanced to the point where it is now possible to integrate storage of 16K bits of information on a single chip of silicon as well as to reliably manufacture chips which contain all circuitry for a 16-bit CPU, the drive towards further microminiaturization of digital circuitry shows no sign of slowing down.

All leading semiconductor manufacturers are preparing to produce even denser circuitry based on smaller circuit elements as well as connecting conductors on the silicon chip. One of the next steps in this direction will be the application of the so-called HMOS technology and related technologies from certain other manufacturers. However, high density technologies (VLSI) are already being discussed and tried out in leading development laboratories.

Conductor line width and geometric design details of circuit elements in these new technologies will drop to 1 micrometer (10^{-6} meter) or less. The leading semiconductor manufacturers have embarked on an effort to gradually increase the density of LSI circuitry to develop the next and subsequent generations of products. The Department of Defense, however, has mounted a major effort to radically increase the density and complexity of integrated circuits so as to obtain the electronic functions they see as crucial for certain military applications towards the end of the decade.

We believe that it is quite feasible, within certain limits, to predict the evolution of integrated circuit technology towards higher density components for the next five years as it might evolve from the current R&D activities of the larger semiconductor manufacturers. It is, however, more difficult to predict what the long-term influence of these DOD programs for the development of advanced semiconductor circuits will have on the offerings of advanced components for commercial data processing applications in the early 1990s.

During the next five to six years, specialized circuits for application in defense-related systems will evolve from these DOD programs. After that period, there is likely to be a gradual commercialization of these initially-specialized programs. We believe that it will be 1987 or 1988 before advanced semiconductor components incorporating the new technologies developed through these DOD programs will become available for use in commercial data processing equipment at competitive prices. Availability of such components will then influence the equipment which will appear on the market by 1989 or 1990 at the earliest.

In the following, we will address a few aspects of VLSI circuitry which are likely to be of importance for future Navy pay system concepts.

1. VLSI Increases Chip Design Costs

Design costs for individual chips increase at least proportionally to the number of individual circuit elements contained in the chip. On the other hand, a higher level of integration means that one chip replaces several chips of a lower level of integration. Therefore, fewer chips are required unless applications are found which demand an even higher volume of these units. This simple consideration makes it evident that VLSI circuitry will increasingly be applied only to circuits of which a high volume of applications are expected. Custom-designs will largely disappear, except for high-cost, high-technology military weapon and control systems.

2. Trend Towards System on a Chip

While LSI technology in the past was aimed largely at the integration of a small part of a complex system, or as far as possible, a small subsystem on a chip, future commercially-offered integrated circuits of high density will offer a subsystem or even a complete system on a chip. This trend is already visible with the one-chip computer, the complete peripheral controller on a chip, and other current devices. Towards the end of the decade, central processing units of present mainframe capabilities will be offered on chips, including on-chip hardware testing capabilities, hardware-implemented operating systems and other desirable features. Also, smaller operating memory systems will be available on chips rather than on boards. In general, integration of a system or comprehensive subsystem on one chip is likely to ease the current conflict between level of integration and requirement for number of pins. In many cases, a higher level of integration will make it easier to limit the number of pins required to interface with the world outside the silicon chip.

3. VLSI Reinforces the Trend Towards Reduction of Power Consumption

Increasing packaging densities in modern electronic systems usually results in difficulties connected with the removal of generated heat. Further, many computer-based systems are expected to operate even during power failures.

Even in instances where such operation is not required, it is often expected that the computer-based system resumes operation immediately after the operating power is restored. In the first case, an auxiliary battery backup for the whole system is required, while in the second case, it becomes more and more widely accepted to provide only a small battery for the backup of the main operating memory. In both cases, sizable reductions in complexity and cost of the backup system are possible if the power consumption either of the total system or of the main memory itself is reduced. It is often considered cost effective to use the relatively expensive but power conserving CMOS circuitry to backup the main memory or even the total system.

The increasing density of VLSI circuitry makes it mandatory for the chip designer to reduce the power consumption of the circuit elements to keep the operating temperatures within acceptable levels. Reduction of power consumption in VLSI circuitry can be accomplished through a reduction in operating voltage.

4. Significance of VLSI Technology for Future Pay Systems for the Navy

In particular, installations aboard ship or in distant locations will benefit from the following applications of VLSI technology:

- Reduction of physical size and cost of the electronic portion of small computer systems and intelligent terminals
- Availability of more processing power as well as main memory capacity in small and very small computer installations
- Reduction of power consumption for small to medium sized computer installations and intelligent terminals by 1990
- Increased availability of equipment

B. INTELLIGENT TERMINALS

Intelligent terminals are usually defined as being user programmable. However, even basic "dumb" terminals are often equipped with microprocessors and have many advanced features, making the distinction between intelligent and dumb terminals less concrete. Further, small business computer systems are quite often based on hardware very similar to that typical of intelligent terminals. For the purpose of this section, we will define intelligent terminals as equipment which is user programmable but which is not meant to perform data processing tasks as its major function. Intelligent terminals thus defined typically consist of the following subsystems:

- Programmable processor
- Visual display unit and keyboard
- Data communication interface
- Bulk memory of floppy disk, tape cassette, small hard disk or bubble memory
- One or more peripherals, including serial or line printers, optical character readers, badge or magnetic card readers, mark sense readers, etc.

Typically, an intelligent terminal uses an integral design approach, with most of the components listed above contained in one or two housings, sometimes mounted on a special desk in order to serve as a complete work station.

1. Typical Applications

Typical applications of intelligent terminals include:

- Input of structured and formatted data. In most terminals, editing and consistency checks on data are often included. Data may be transmitted immediately, in large or small blocks, or stored until transmitted in batch mode.

- Access to remote data bases or other remote files and display of information transmitted from a distant location. This information is also usually displayed and/or printed in a highly structured or formatted way, controlled by the terminal processor.
- A combination of the above modes of operation. The operator is guided to make certain inputs and/or or inquiries by a series of fixed forms which are displayed consecutively on the screen prompting the operator to make "menu" type selections. The content of the forms may be stored locally in the terminal or may be received from the remote computer.
- Local or remote peripheral activation. Depending on the program used in the terminal, activation of the local peripherals, such as printers and input devices, may be under the control of the local operator or of the remote computer.

2. Typical System Configuration

In the following, we will describe the various subsystems of typical intelligent terminals. These descriptions apply to the present generation of advanced systems and will, in our opinion, change only slightly over the next decade. Where applicable, we will point out areas where technology may develop in different ways.

Display Units

Currently, and for at least the next decade, the standard visual display technology will be the CRT. This display may be augmented by the addition of a limited graphics capability. This limited capability would include only the display of horizontal and vertical lines, characters of various sizes and type fonts, and a few additional symbols such as special logos. Very little additional circuitry is required to implement such capabilities. We do not believe

that full graphic capabilities, which allow drawings or complicated illustrations to be displayed, will be necessary for general purpose intelligent terminals.

A limited graphic capability would be used to produce structured forms which prompt the operator to supply data in blank fields. An example of this type of application would be the processing of an insurance application. In this case, a hard copy of a completed form might be necessary. In many present applications, however, there is only a superficial resemblance between the layout of the actual printed form and the layout of the free display. The formatting routine on a local printer has to take care of the task of positioning the information relative to the preprinted form. There is currently a trend towards lower cost printers with graphic capabilities, employing non-impact technology. Such printers allow printing of the basic forms in the original form layout together with the inserted information at no penalty of cost or throughput. We believe that in the future, intelligent terminals with such printers will be used extensively. It would be highly advantageous for the form to be stored in memory and displayed in approximately the original layout on the screen. After all editing is completed, the printing would be initiated. Section H of this chapter contains further information on terminal displays.

Keyboard

A keyboard is usually incorporated into intelligent terminal systems, featuring full alphanumerics and an additional ten key numeric key pad. The keyboard is the main operator interface for interaction with the system. Only very specialized applications of intelligent terminals do not require this device. Information typed on the keyboard is always considered input to the terminal processor. It is usually not transmitted directly character-by-character but rather a transaction is keyed and assembled prior to transmission.

Terminal Processor and Memory

At present, an 8-bit microprocessor is sufficient for most terminals. Intelligent terminals are intended for applications where numbers or text in alphanumeric form are manipulated, sorted and otherwise processed. Many existing intelligent terminals use 7 or 8 bits of memory to store one character with from one to five additional bits associated with each character to denote special display options. These options include blinking and increased brightness, as well as the type of field in which this character is being used (numeric, protected, etc.). In the future, 16-bit processors may be used to process words of more than 8 bits which include these options and require a higher throughput.

Early designs of intelligent terminals often used one main processor which, in addition to executing the local user program, had to perform the functions of display refresh, screen formatting and communicating with the data line. The decreasing cost of microprocessors, as well as increasing demands for performance, has delegated these tasks to separate microprocessors. Most newly designed intelligent terminals include a variety of microprocessors, with one such unit entirely dedicated to the execution of the user program. Display refresh, data communication functions, input and output to peripherals, control of disk and tape units, etc., are increasingly performed by individual specialized microprocessors.

Main processor memory has to be of sufficient size to store the user programs as well as the data. We expect that user programs will increasingly consist of "canned" software contained in read-only memory (ROM) and programmable read-only memory (PROM) modules and software loaded into random access memory (RAM) from either local disk or tape devices or to the data communication line. Presently, intelligent terminals use main memory in the range of 4K bytes to 64K bytes. It is likely that even larger memory sizes will be used in the future as the cost of memory decreases further.

Certain intelligent terminals on the market offer an optional character string processor. These processors are used to efficiently manipulate character strings, for example, moving them from one memory location to another while the main processor performs other tasks.

Specialized processors for arithmetic operations are already being offered by various semiconductor manufacturers. It appears feasible to include such processors in order to improve the arithmetic capabilities of a standard 8-bit microprocessor whenever number processing capabilities are needed to any extent.

Data Communication Subsystem

Early intelligent terminals used a universal asynchronous receiver/transmitter (UART) to interface with a modem. The main processor was then responsible for input and output between main memory and the UART.

Synchronous transmission was used mainly when communicating with larger mainframe computers, particularly of the IBM brand. For these applications, a very complicated, hardwired bi-sync interface replaced the UART. Today, synchronous transmission is slowly becoming more popular because of increased throughput, complete transparency for all bit patterns, and the upcoming new transmission protocols like SDLC, HDLC, and X25. The availability of synchronous protocol-oriented interfaces (UART replacements) on LSI chips has further served to popularize synchronous transmission.

Packet switching is becoming very popular in many public data networks throughout the world. Its introduction as a public service in the U.S. appears to be somewhat slower, but it is used for many specialized commercial and military data networks. Direct packet switching network interfaces are rarely offered today on intelligent terminals but will become a necessity by 1990.

Some recently designed intelligent terminals offer a variety of modular data communication interfaces. These interfaces consist of a printed circuit (PC) board containing a dedicated microprocessor which interfaces through direct memory access with the main memory and controls the flow of information,

and a specialized protocol-oriented data line interface. Special software, usually implemented as firmware in PROM, is used with the data communications processor, which operates under the supervision of the main processor.

Data communications interfaces of this type are already being offered with some intelligent terminals for asynchronous transmission, synchronous transmission in bi-sync format, synchronous transmission in SDLC format and for other protocols. We expect that such interfaces will become available for a larger variety of protocols, including packet switching.

On-Line Bulk Storage Devices

The first generation of intelligent terminals made widespread use of magnetic tape cassette devices for the purpose of storing collected or preprocessed data temporarily until they were transmitted to a central location in a batch mode. At present, and presumably for many years to come, intelligent terminals will have on-line bulk storage capabilities with or without removable media, depending on the application. This capability will be used for:

- Software storage either to compensate for the semiconductor-based main memory or in an overlay fashion, to utilize software systems too large for the main memory capacity
- To implement local data bases and files which have to be frequently accessed and/or updated locally
- As a means for temporary storage of data which are either collected and/or preprocessed at the terminal and have to be temporarily stored for later transmission, or data received from the central computer and temporarily stored for data printout

A standard audio tape cassette was initially used exclusively for these applications. Because of their limited capabilities, they were soon replaced to a large extent by two sizes of 3M data cassettes. However, while tape cassettes are well suited for temporary storage of data in sequential order, they are awkward as random access devices and, therefore, slow and cumbersome.

In the meantime, 8-inch floppy disks and later 5 1/4-inch floppy disks became widely accepted and available for prices below those of the 3M cassette units. Floppy disk units are designed to operate in random access mode and are well suited for any of the above mentioned applications. Further, they are an inexpensive and removable media which allow the storage of records, backup files and software sections or systems by keeping the diskettes in a file in the office.

Eight-inch and 5 1/4-inch diameter diskettes originally were capable of storing 400K bytes and 120K bytes. These figures are net storage capacity in industry-compatible format. Subsequently, optional double density recording and double-sided drives and media were developed and found industry-wide acceptance. Each of these improvements doubles the net storage capacity of either the 8-inch or the 5 1/4-inch drive.

The only major drawback of floppy disk storage in this application is the relatively long access time when compared with conventional hard disk units. Hard disk units, at least those of the conventional type, are usually considered far beyond the allowable cost range for most intelligent terminal applications.

Winchester Disk Drives

Very recently, Winchester-type fixed disk drives have been developed and have found an enthusiastic acceptance, particularly in connection with microprocessor systems. Devices of this type are relatively inexpensive and present usable storage capacities from approximately 4 megabytes to between 20 and 30 megabytes. Future developments are expected to increase this range of capacities.

We expect that Winchester 8-inch hard disk drives will be offered with intelligent terminal systems in the near future. Their shorter access time and high mechanical reliability should prove quite attractive for all applications except those where removable media are required. In such cases, either a floppy disk or a combination of a floppy disk and a Winchester drive would be necessary. The latter configuration would allow use of the floppy disk as an input and output medium, while the Winchester disk would serve in all high speed random access operations necessary in connection with fast access to software modules, files, data bases, or other information within the intelligent terminal.

Bubble memory will soon become available for general applications. However, its long term cost trends, and therefore its place in comparison with semiconductor memory, electromechanical magnetic storage devices, etc., are not well established. We expect the cost of bubble memory per bit to be much higher than that of 8-inch Winchester drives or floppy disk drives for quite a number of years. This makes it difficult for bubble memory to compete with such devices at their range of capacity. However, at capacities between 50,000K bytes and up to possibly 200,000K or 500,000K bytes, bubble memory is likely to be less expensive than a Winchester mechanism. Since bubble memory is non-volatile, it might be the ideal medium for the storage and reloading of software in remote terminal locations which otherwise do not require random access devices.

Intelligent terminals are already on the market with integral floppy disks featuring either single or dual drive mechanisms. Since many of the upcoming Winchester drives are built to the same mechanical dimensions as 8-inch floppy disk units, it should prove easy to offer a choice of any mixture of floppy and Winchester drives in one intelligent terminal.

Printers, Optical Character Readers and Other Input/Output Peripherals

Printers and sometimes batch readers, mark-sense card readers and magnetic card readers are often physically integrated into the terminal. This integral design might save some of the costs necessitated by separate housing, power supply and interconnecting cables. But unless the anticipated application requires a large volume of terminals, such integration might not always be economically justified. Another way of decreasing costs is to design a special desk which contains not only the terminal but also the application-related peripherals to constitute a single work station.

At present, character printers are more popular in applications requiring a high quality output while low to medium speed line printers are preferred for most other applications. We expect that full page printers based on non-impact technology will become available in a low enough performance and price range to be of interest in intelligent terminal systems in the future. Such printers will prove to be quite attractive not only because they are quiet but also because they can print a full page at a time, including not only the data output but also all details normally contained in a preprinted form. This will be possible without any penalty in terms of decreased throughput or increased cost. Thus, the requirement for local storage of preprinted forms, possibly of many different kinds, can be totally eliminated.

3. Technology Trends

The design principles and configurations just described are currently not implemented in many of the most widely sold types of intelligent terminals. Only some of the most recently designed terminals incorporate one or more of these principles. However, we forecast that most of the general purpose intelligent terminals will be built along these lines within the next few years. Subsequently, cost reductions can be expected from the long-term trend towards larger scale integration and lower component cost of microprocessors, memory chips and other specialized functions used in intelligent terminal systems.

Technologically-derived cost reductions of this kind not only will reduce the cost of a system with given specifications, but will inspire product designers to include capabilities previously found only in more expensive systems. Developments of these kinds might lead towards increased capabilities for intelligent terminals in the area of more throughput for local data processing and the capability to implement larger local files and data bases and search them efficiently.

4. Cost Trends

Overall terminal costs can be expected to decrease because of the decreasing costs of electronic components, particularly large scale integrated circuits used to implement main memory, microprocessors and input/output and data communications controls. Further, decreases can be expected from generally higher volumes achieved through wider acceptance of all types of intelligent terminals within the commercial marketplace.

In order to present the expected cost trends, we have assumed two standard configurations for intelligent terminals. Exhibit VIII-1 shows our forecast for the price trends for two types of intelligent terminals:

- One terminal (1A) contains a 12-inch CRT display, keyboard, 5 1/4-inch floppy disk unit, 16K bytes of main memory, advanced 8-bit microprocessor, I/O controllers for the floppy disk unit and for an external printer, as well as a data communication controller capable of supporting SDLC over a wide range of transmission speeds.
- The second terminal (1B) has the above features but has 64K bytes of memory. Further, it uses an 8-inch floppy disk drive in addition to an 8-inch Winchester drive. Initially, the Winchester drive is assumed to have a capacity of 4 or 5 megabytes, which will increase over the time period shown in the graph

towards the 20 to 30 megabyte range. This unit incorporates limited graphic capabilities allowing the storage of the complete layout of many different forms which may be displayed on the screen and printed on an external full page printer.

Cost figures presented in the graph exclude the desk and all external, optional peripherals such as printers, OCR readers or other input devices.

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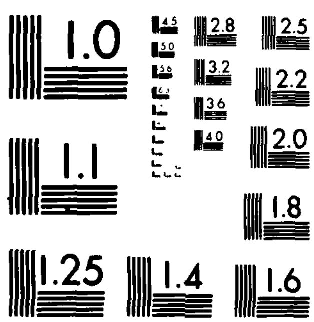

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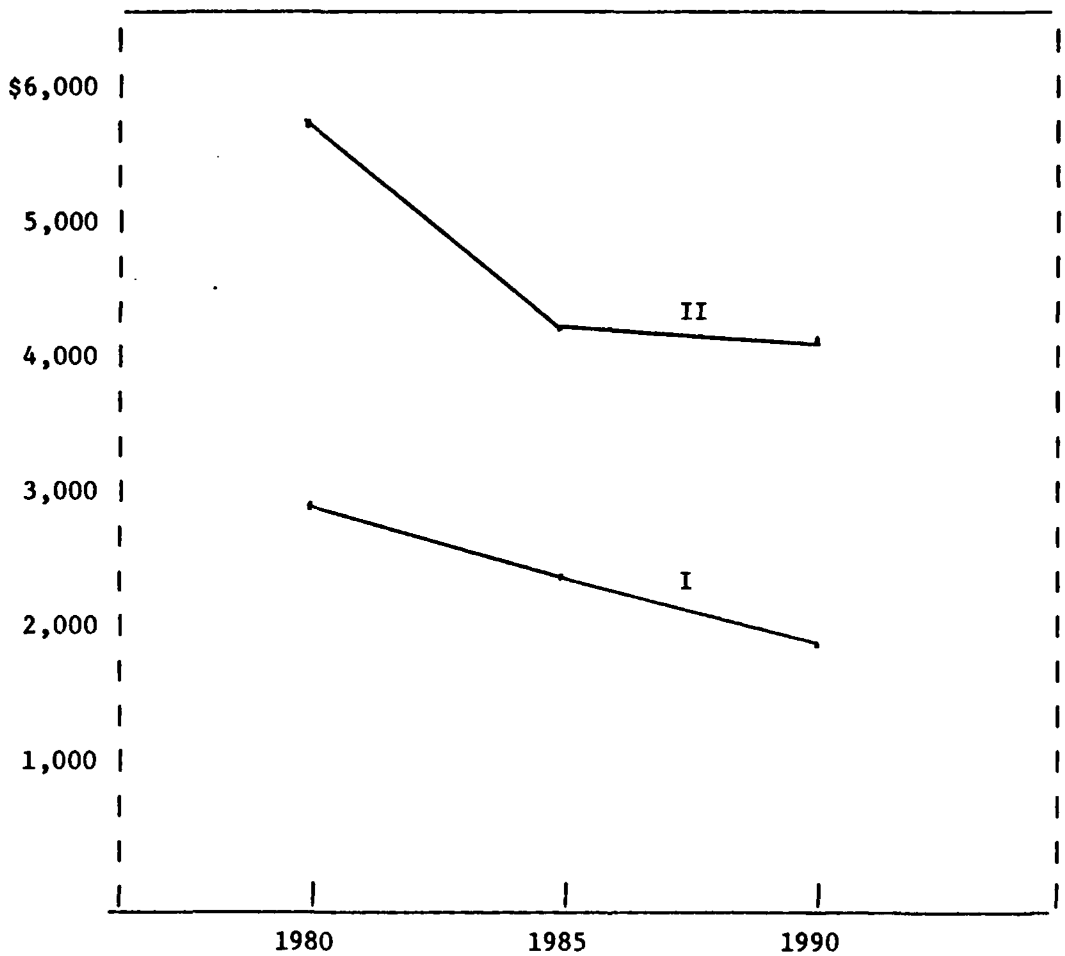
PRICE TRENDS OF TWO REPRESENTATIVE INTELLIGENT TERMINALS



I. Intelligent terminal with minifloppy disks, 16K bytes memory, SDLC interface, 12-inch CRT with keyboard.

II. Terminal as in I but with 8-inch floppy disk, 8-inch Winchester drive and 64K bytes of memory.

EXHIBIT VIII-1

C. OPERATING MEMORY

Main operating data memory today uses almost exclusively semiconductor Random Access Memory (RAM) integrated circuit components. Core memory has largely disappeared. We believe that this trend is going to continue through the 1980s. Constantly increasing levels of integration will make memory systems less expensive and more compact. However, there is presently a strong trend towards the use of ROM for storage of programs or program segments. This trend is also likely to continue, at least for certain widely-used application programs and a large section of the operating system software.

1. Random Access Memory (RAM)

Currently, the most popular memory chip contains 16K bits of storage capacity. This chip is still based on conventional LSI technology. Several leading manufacturers have already announced the next denser memory chip, containing 64K bits. This component is expected to become available and accepted in 1981/1982. The next higher level of integration, containing 256K bits on one chip, is likely to become available in 1985 or 1986.

These levels of integration already use advanced VLSI technologies and include not only an assembly of storage cells together with addressing logic and power drivers but also other essential memory system components as error correcting logic, self-testing capabilities and others.

We are quite confident that the increasing density of memory components will not stop with the 256K-bit chip. Extrapolating the current trend towards higher level of integration, we can expect a chip capable of storing 1,000,000 bits or 100,000 bytes in the early 1990s.

Wafer-scale integration is a topic of great practical debate. Here, the idea is to use a silicon wafer, a disk of between 3 and 5 inches in diameter, as a base for manufacturing integrated circuits. Many individual integrated circuits would be implemented on such a wafer and interconnected to form the desired system.

Such techniques would be used to achieve redundancy by initially providing more circuits of each type on the wafer than needed for systems implementation. If some individual circuits do not meet the manufacturing specifications, they would be "replaced" by circuits located somewhere else on the wafer, through selective intra-chip lead deposition.

Wafer-scale integration is a method for building very small and very dense memory systems. However, we think that small computer installations or computer terminals will not require the memory sizes achievable with this technology even in the early 1990s.

Ultimate Technologies

Charged couple devices (CCD) use a very dense technology to achieve a number of shift registers on one silicon chip. These devices have been proposed for the purpose of large capacity, high density memory applications. However, it appears that they will be largely superceded by the current and expected future developments of dynamic RAM elements. It should be noted that several of the improvements incorporated into the upcoming 64K-bit chips, and most likely into the next generation of higher density chips, can be considered derivatives of technology developed initially for CCD applications.

Trend Towards Lower Power Consumption

Increasing density of memory chips is only technically feasible if power consumption per unit of storage is lowered, otherwise, heat build-up would be excessive. This trend to lower power consumption will be very useful for memory systems which need to be kept "alive" during power failures. The method used is inclusion of a small battery, often on the memory printed circuit board. Apparently, only static RAM chips, preferably of the CMOS type, can be backed up with inexpensive batteries for up to several hours at a time. However, static memory and CMOS elements, are normally more expensive than standard dynamic memory chips. It is probable, however, that power consumption of standard dynamic memory chips will decrease towards the levels achieved with these special memory elements, when viewed as power consumption per unit of storage capacity.

RAM Cost Trends

Dynamic RAM memory chips with 16K-bit capacity currently cost between \$4.50 and \$5.50. It is expected that the 64K-bit chips, when initially introduced, will cost at least four times as much. When the new chip is in full volume production and achieves a high yield, its price per chip is likely to be equal to that of the current technology, effectively cutting the cost of storage capacity by 75%. We may reasonably expect that a similar cost reduction per unit of storage capacity will occur with the introduction of the 256K-bit chip and with the next higher density successor.

Today, typical printed circuit board-based memory systems cost approximately 2.5 to 3 times the cost of the memory chips themselves. This cost relationship is likely to remain approximately the same throughout the decade, provided that the capacity of the memory system on one board increases according to the higher capacity on the individual memory chips.

2. Read Only Memory (ROM)

ROM of different types and technologies has become increasingly popular to store software. Software stored in this way is usually referred to as "firmware" or "canned software." ROM storage is used frequently for systems software in small computer installations and intelligent terminals as well as for the implementation for microinstructions in central processing units. There is a strong trend towards implementing more types of software in this way. In the future, systems software for larger computer systems, as well as all frequently used sections and modules of application programs will be stored in ROM modules.

There are several advantages to be gained by use of this technology:

- Program storage is not affected by power failures.
- ROM storage, particularly of the mass programmed variety, is relatively inexpensive when compared with standard RAM technology.
- ROM is a compact way to store software and to distribute it to individual installations by the manufacturer.
- Software stored in ROM is not easily copied by the user or used in unauthorized ways.

There are basically three types of ROM storage devices:

Mask Programmable ROM

This type of device permits the storage of software or other information during the manufacturing process. One of the masks necessary for this process is custom made to implement the desired information into the ROM.

The process requires substantial front-end costs for the fabrication of the special mask, but is the least expensive ROM technology as far as the production for subsequent devices of the same initial program type is regarded.

Currently, mask programmable ROM memory chips are available in a large variety of size configurations up to 64K bits per chip. It is currently feasible to manufacture large capacities per chip, however, there does not seem to be much need for these large sizes at present.

Increasing popularity of "canned software" is likely to result in larger units of ROM towards the end of the decade. Chips with 128K- or 256K-bit capacity each will possibly become available at attractive prices.

Mask programmable ROM chips of 64K-bit capacity currently require a masking charge of $8,000 plus between $10 and $15 per chip, depending on quantity. We believe that these prices reflect the still relatively low volume of manufacturing achieved with this technology.

Reduction of price per chip by 50% for 64K-bit capacity and even lower cost per unit of storage capacity for higher capacity chips will easily materialize toward the end of the decade. However, masking charges are likely to go up significantly for these larger configurations.

<u>Programmable Read Only Memory (PROM)</u>

Current PROM is available in two versions. One may be field programmed but does not allow later modifications. The other version, featuring a quartz window, makes it possible to erase the content of the memory by exposure to a strong ultraviolet light. After that, the device may be programmed again with any desired information.

These two devices are currently available in capacities of up to 32K and 64K bits per chip. They are quite popular for application in ROMs where later changes are expected, or where the expected low volume makes the application of masked PROM uneconomical.

<u>Electrically Alterable Read Only Memory (EAROM)</u>

Electrically alterable read only memory, also often named electrical erasable read only memory, has recently been introduced and is becoming quite popular. Such devices are based on a few recently developed semiconductor technologies and are still relatively expensive. However, they have the potential of becoming less costly than the present ultraviolet light erasable device which requires the expense of the quartz window.

EAROMS can be erased and reprogrammed with the application of electrical signals. Power levels for this process are relatively modest; it is quite possible to incorporate the circuitry necessary for erasure and reprogramming

to a memory system. However, this change of information contained in the memory requires more time than changing the content of a standard dynamic RAM memory system.

While prices of an EAROM are currently compatible with ultraviolet rays, we feel that in the second half of the 1980s and 1990, such devices will be available competitively with standard dynamic RAM of the same capacity per chip.

It is feasible that EAROM could be designed for storage with much more than 64K-bits per chip. However, we believe that within a few years the desirability of such large capacity chips will determine their availability. For applications of program storage, it is certainly desirable to store individual software modules in separate chips. Many software modules, however, will not require more capacity than 64K bits.

3. Relevance of Operating Memory Technology Trends to the Configuration of Future U.S. Navy Pay Systems

Decreasing cost and increasing density of dynamic RAM memory technology will allow the deployment of small remote computer installations or intelligent terminals with operating main memory capacities without excessive operating memory cost. While currently many installations are limited to between 16K and 64K bytes of memory, by 1990 one half megabyte and up to several megabytes of memory will be economically feasible.

Decreasing power consumption of operating memory will allow the packing up of the complete memory with an inexpensive, small battery in order to keep the memory "alive" during power system failures.

Decreasing cost of ROM and EAROM will help increase the popularity of "canned software" or firmware in future small computer installations in intelligent terminals.

Portable Electronic Pay Record Feasible

The very small size and low cost trends for semiconductor memory makes feasible a thick credit card-sized memory system capable of storing easily up to 10,000 bytes in a 2-3 chip system, which would include a microprocessor for access (security) control and other control functions. This device could store the entire MPR in a fully portable form, capable of being read by any authorized computer system. The card could be updated only upon receipt of an encryption key provided from a centralized facility, such as NAVFINCEN.

D. CENTRAL PROCESSING UNITS (Small Business Oriented)

1. Introduction

During the 1950s and most of the 1960s, advancement of computer technology had been largely confined to increasing the memory size and performance of large mainframe computers. EDP needs of smaller businesses were generally delegated to computer service organizations.

A new development was initiated during the mid-1970s by production of DEC's highly successful PDP-8 minicomputer. This event finally led to the establishment of a whole new industry of minicomputer manufacturers. At DEC, more powerful models of minicomputer, such as the PDP-11, were developed. Other manufacturers, some of them newly founded, followed with comparable products. Among these manufacturers were Hewlett-Packard, Data General (NOVA) and Varian.

For many years, minicomputers were used mainly for scientific, technical and industrial control applications. Although minicomputers were generally available, including suitable mass storage devices and input/output peripherals for application for small business needs, they were not widely used for this purpose. One of the reasons for this was the high cost involved with the necessary application software. Available software packages, as a rule, were written for large mainframe computer installations and could not be used on minicomputers. More primitive system software and software development tools quite often made the writing of an application software package more difficult and costly for a minicomputer than for larger mainframe computers such as the IBM 360/370.

During this time period, a distinction between minicomputers and mainframe machines was easy. There was a wide gap between the capability, memory size and other performance-related specifications of a PDP-8 and even the smallest member of the IBM 360/370 family. This changed during the second half of the 1970s. Additionally, the microcomputer emerged from its initial applications in pocket calculators and as a dedicated controller for specialized applications

into a general purpose processor reaching, and even surpassing, the performance of many earlier minicomputers. This is a trend which is expected to continue.

Minicomputers in general have expanded their capabilities in several ways. Decreasing cost of memory now allows equipping moderately-priced minicomputer systems with memory systems larger than those found in many large computers ten years ago. Technological advancements in the area of large scale integration allow equipping relatively low cost minicomputer CPUs with performance specifications far beyond those customarily found in minicomputers only a few years ago. At the upper price range, processor capabilities now include full 32-bit word lengths; extensive and detailed instruction sets, including hardware multiply and divide and hardware floating point arithmetic; hardware aids for memory management; as well as virtual memory; much faster cycle times (down to less than 500 nanoseconds); hardware capabilities to support multiprogramming; etc.

System sizes and capabilities of microcomputers, minicomputers and so-called mainframe computers overlap to the extent that clear system classifications are difficult.

2. Small Business Computer Systems--Present State of Technology

We define a small business computer system as a scaled-down computer system suitable for the needs of the small business or for a smaller division of a department of a larger corporation. Two or three years ago, it was customary to classify computer systems as small business oriented when their turnkey price, including reasonable amounts of application software, was in the range of $5,000 and $100,000. At present, however, it appears that advances in technology have been such that systems for very small businesses are available well below $5,000 and systems for around $100,000 are rapidly becoming capable of serving businesses which cannot be regarded as small.

In the following discussion, we will confine ourselves to systems based on general purpose computers excluding so-called electronic accounting machines.

Vendors of Small Business Computer Systems

Small business computer systems are currently being offered by four distinct groups of vendors. The first are major corporations well known in the field of computers such as IBM, Burroughs, NCR, and Honeywell. Many of these companies have had considerable success in this product area. For Burroughs and NCR, small business systems now account for a remarkably large share of their sales volumes.

The next group of vendors are the typical minicomputer manufacturers such as DEC, Data General, Computer Automation, Hewlett-Packard and Wang. This group of manufacturers has watched the small business systems market carefully for years. Several manufacturers have supplied either minicomputers, peripherals, or even packaged hardware systems to systems houses. Recently, however, most of these manufacturers have begun to offer minicomputers in a packaged system, including application software, and almost always, a large variety of operating systems, compilers and other basic supporting software for people planning to do their own programming.

The third group of vendors consists of the so-called system houses or turnkey system vendors. These include companies like Basic/Four, Qantel, STC Systems, and Mini-Computer Systems. This group operates in a fashion similar to the second group. The main difference between the minicomputer manufacturers and the system houses is that typically the turnkey vendors buy the minicomputer and peripheral hardware from established manufacturers. In addition to systems integration services, application related software and often specially designed supporting software is offered as part of the package to the end user.

Microcomputer manufacturers comprise the fourth group of vendors. Many of the companies in this group began building microcomputers for one specific application or another and finally decided to expand into the small business systems market. This last group of system vendors is still in the formative stage and, in most cases, not yet well established. Interestingly, some larger companies, for example, Radio Shack and Schlumberger-Heath Corporation, both

of which initially started to offer microcomputers for home and hobby applications, are now expanding quite aggressively to the small business system market.

IBM

System houses have provided minicomputer-based small business systems at a relatively low volume for quite some time. Some have even designed a small scale system around a programmable "intelligent" computer terminal. IBM, however, has risen to a position of relative market leadership, at least in the larger size ranges of systems. The vehicle of entry for IBM was the System 3, originally introduced in 1969. System purchase prices at that time ranged from approximately $30,000 to above $250,000. IBM System 3 has achieved a sales record in computer history, with approximately 40,000 installations worldwide.

In 1975, IBM introduced the new System 32. This is currently the smallest and least expensive general business computer available from IBM. All system components, including processor, memory, keyboard, CRT display, printer, as well as mask storage and floppy disk drives are housed in one single, desk-shaped assembly. The price for IBM's System 32 starts at $30,000. The manufacturer offers a wide range of application software packages for many different industry environments.

In 1977, IBM announced System 34. When compared to System 32, System 34 has a larger memory capacity, more processing power and disk storage capacity. Most importantly, however, System 34 has the ability to support up to a total of eight independent multiprogramming supported work stations. Burroughs and NCR are the next most successful vendors in this market area, having supplied this market longer than IBM.

DEC

DEC, the most successful U.S. minicomputer manufacturer, has been offering packaged versions of their popular PDP-8A and PDP-11 and LSI 11 minicomputers configured as work stations. (The LSI 11 is a microprocessor-based low cost

implementation of the PDP-11/34 instruction set.) These packaged versions, which were available with a basic operating system, compiler and other supporting hardware, were generally intended for system houses which would write the appropriate application software for business as well as educational applications and provide the necessary end user support function.

In 1975, however, only a few days after IBM introduced the System 32, DEC offered their Data System 310, which is based on a packaged PDP-8A, augmented by a CRT console, two floppy disk drives and other peripherals. The basic system price of Data System 310 was approximately $15,000. DEC has since introduced several other, more powerful packaged business computer systems, featuring either the LSI 11 or the more powerful PDP-11/34 processor. Technologically similar systems with comparable prices and capabilities are being offered by Hewlett-Packard, General Automation and Harris.

Specialized Systems

Currently, a large number of systems houses and software vendors are offering packaged/turnkey business computer systems. Usually none of these vendors, however, is manufacturing either computers or peripherals themselves. They often can provide very optionized systems to certain groups of end users. One reason for this is that many vendors have a proven record of providing exceptionally good software for specialized application areas. Further, they have the opportunity to compose a hardware system out of the total market offerings of not only computers but also all types of peripherals. These specialized systems rely on off-the-shelf computer hardware and do not generally contribute to the advance of technology. Hence, they are of little interest for our technology survey.

The entry of microcomputer manufacturers into the business system market is more recent. We do not necessarily count in this group vendors who use either the DEC LSI 11, the lower-end Data General NOVA computer or similar devices from other minicomputer manufacturers. Such devices are specially designed to be upward software compatible with existing minicomputer product lines and are integrated into each company's line of products, although the processor chip set is often not manufactured by the minicomputer vendor.

Typical minicomputer manufacturers in this sense purchase existing chip sets from semiconductor houses and build minicomputer systems, including semiconductor memory, interfaces for peripherals, etc. Several companies have entered this branch of business in order to provide minicomputers either for specialized industrial applications or, more recently, for the growing home and hobby computer markets. The latter group soon discovered that the low entry threshold into the home and hobby computer markets allowed relatively large numbers of start-ups to offer many different kinds of products. Several of the more powerful vendors of such products soon discovered that the home and hobby computer market is not growing as fast as initially expected by some observers. Companies with a strong enough financial background started to branch out into the small business system application, by repackaging their existing microcomputer systems into suitable packages, including applicable peripherals, operating system and other supporting software, as well as a growing number of application software packages. Most notable among these microcomputer manufacturers are two large companies, Radio Shack Division of Tandy Corporation and Schlumberger/Heath.

Radio Shack

Radio Shack introduced their PRS 80 home and hobby microcomputer a few years ago. This system is based on the Zilog Z80 microprocessor chip. The current configuration consists of an alphanumeric keyboard, a converted small screen black and white TV set as a display unit and the computer with 16K bytes of semiconductor memory. This system sells for approximately $850 and includes an electronic interface to a standard cassette audio recorder which allows storage and retrieval of software and data, and a firmware implemented version of the basic programming language adapted for use on this microprocessor. This PRS 80 home and hobby computer, which is supported with very detailed documentation, has been sold by Radio Shack so that approximately 112,000 units of varying size and configuration are in service. Observers of the market believe that a considerable proportion of the owners of this system use it for professional or business related purposes, often relying on special user-developed software.

Radio Shack has confidence in the business application of the PRS 80, because it has recently announced a version of this system packaged specifically for business applications. This system offers a basic configuration of 32K bytes of memory, expandable to 64K bytes with keyboard and CRT unit. In addition, two 8-inch floppy disk drives are included as well as a line printer, capable of printing 120 characters per second on 13-inch wide paper. This whole package, including the necessary disk operating system, basic interpreter and other supporting software, sells for approximately $4,000 and is configured into a desk-like work station. Radio Shack offers a wide selection of well-documented business application program packages. Further, large numbers of low-profile vendors also offer many different software programs and total packages for general or specialized business applications of this computer.

Schlumberger/Heath

The second and more recent entry into this field is Schlumberger/Heath. This company has offered home and hobby computers in kit form for several years, including a version of DEC's LSI 11. This company's new product, its first for small business systems applications, is the recently announced H89 computer. This unit looks like a CRT console terminal, featuring a high resolution CRT tube and an alphanumeric keyboard with additional numeric keypads, as well as an integrated 5 1/4-inch floppy disk unit. The basic memory is 16K bytes expandable to 48K bytes. One Z80 microprocessor is used to provide many sophisticated display functions, while a second Z80 microprocessor serves as the user programmable device. The unit supports various character and line printers, optional data communications interface, and additional floppy disk units. The computer is available with an initial range of basic business related software packages at a nominal additional cost per package. The price of the hardware including a total of 32K memory, but excluding a printer, is approximately $2,400.

Summary

In our opinion, the main differences between offerings from IBM or from DEC, for example, in a certain size range of small business systems are the

available application software, short and long range customer support, customer education, and product promotion. Certainly, total turnkey price is also an important consideration. The most interesting recent entries, however, appear to be at the lower size ranges of business systems, with new systems based on microprocessor technology. We expect to see this trend continue with the focus of innovation being at the lower end of the size range. We therefore believe that this segment of the market is the most interesting one to watch for technological innovations.

3. Hardware Versus Software Technology--Which is the Driving Force?

The high cost of programming small business computer systems compared with the cost of the hardware configuration itself is usually considered responsible for the long delay in the acceptance of such systems in the marketplace. In general, small computers tend to have simpler instruction sets and less sophisticated supporting software, resulting in reduced efficiency of application programming teams. This fact becomes particularly important when microcomputer systems based on the Intel 8080 or its slightly more capable successor, the Zilog Z80, for example, are considered. Implementation of higher level programming languages such as COBOL, FORTRAN and others are either not available, inefficient or otherwise restricted in their usefulness. These facts plus the simple architecture of the processors do not allow direct utilization of existing software packages, even if a compiler for the specific higher level language exists for that machine. Although some microprocessors are upward software compatible (8080 and Z80 for example) the availability of a FORTRAN compiler for two different typical 8-bit microprocessors in no way means that programs become "portable" between these two machines. Programming for the present generation of 8-bit microprocessors has to take into consideration the specific architecture of each to such a degree as to prevent portability. Portability has to be achieved to some degree, however, before small business computer systems can be afforded by many potential users. It is prohibitive to have to write not only different application packages for each specific industry but also each interface-specific package in as many different versions as microprocessors exist on the market.

There are two separate technological trends which can be expected to improve the situation just described. In the section of this chapter dealing with LSI and VLSI technology, we discussed the current trends in microcomputer technology. One-bit microprocessors or microprocessor chip sets are becoming available which will have instructions sets surpassing, in some instances, those of many present medium sized minicomputers. Since the cost of the CPU in a microprocessor-based business computer system is a relatively small portion of the total hardware cost, we would expect that more powerful processors will soon replace the first and second generation processors of the 8080 and Z80 types. This development brings inexpensive microprocessor-based computer systems into the performance range of today's IBM System 32 and 34, as well as DEC's PDP-11 and LSI 11 based systems, but at much lower costs.

The second development is in the area of software. For today's minicomputers of the class represented by the PDP-11/34, and the more powerful NOVA computers, application program portability is usually not easily achieved. This is particularly true when the manufacturer-provided operating system and compiler packages are used. We consider this to be a fact brought about partly by chance and partly by design.

There is, however, one surprisingly complete and comprehensive software system which originally was developed with Bell Laboratories for internal use. The proprietary name for this sysem is UNIX. This system, which includes operating systems, compilers, compiling generating software and a long list of utility programs has been specifically designed by Bell Laboratory software experts to achieve a reasonable degree of portability between different commercial minicomputers. No effort has been made by the Bell Laboratories, however, to market this system commercially. It has been provided for a nominal fee for use by universities and other non-profit research institutions and has been sold for a license fee to some commercial users. We understand that many current users are enthusiastic about the possibilities of the UNIX system.

Both trends, the evolving more powerful and uniformly structured microprocessor, as well as the potential trend towards universally applicable supporting

software may well converge in the future in a way which will allow a high degree of application software portability. We believe that a step in this direction is already becoming visible. The relatively new PASCAL higher level programming language, which is based on many useful features of ALGOL, has been designed with the smaller computer system in mind. PASCAL is a very powerful language which is reported to boost programmer efficiency considerably. An interesting feature of the version of this language developed at the University of Californi›, San Diego (UCSD) is the use of an intermediate step of the compilation of this language. A compiler translates the PASCAL source code into the intermediate "P" code. The P code may be considered a machine language written for a specialized processor with a relatively complex and efficient instruction set. Most computers utilizing PASCAL of the UCSD variety now utilize the UCSD compiler then execute the P code with the aid of a P code to machine code interpreter. The semiconductor manufacturer, Western Digital Corporation, has developed a special microprocessor chip set which directly implements the instruction set necessary to execute the P code without the help of an interpreter. The result is a surprisingly fast and efficient execution of programs originally written in PASCAL. The Western Digital chip set is based on 16-bit word lengths and is equivalent in performance to present day medium sized minicomputer processors.

There are strong indications that the PASCAL programming language is gaining fast in popularity. For example, the CCITT recommended programming language called CHILL for SPC telephone exchanges is based on a modified version of PASCAL. It is too early to forecast whether PASCAL will catch on with the traditional EDP community. There is some indication, however, that application software for small microprocessor-based business systems will be written by a new group of software experts instead of by traditional EDP programming teams.

4. Future Hardware Technology Trends

We have pointed out that certa'n trends in software and hardware technologies are likely to result in higher efficiency of programming teams, as well as a certain degree of portability of application software. These trends are very important. We believe that the success or failure of business computer systems

of the smaller size classes will depend on the achievement of such goals. If a high penetration of the marketplace by relatively low cost small business systems can be achieved, the resulting high volume of production for electromechanical peripherals such as printers, floppy disk units and hard disk drives will in turn help to further reduce the cost of these devices. This market penetration, rather than further cost reductions of semiconductor devices, will help reduce the purchase price of small business computer systems.

In this section, we point out technology trends which are of particular interest for small business system applications and combine the cost trends of all the various system components (discussed in other sections of this chapter) in order to arrive at a forecast of the anticipated total system cost throughout the forecasting period.

Main Memory

In our section covering LSI and VLSI technology trends, we pointed out the recent dramatic advances in this technology which have resulted in considerably less expensive semiconductor memory systems. This trend is expected to continue throughout the decade. As a result of this development, core memory has almost disappeared from the scene; even the newly developed bubble memory does not appear to be able to compete in price with semiconductor memory for at least the next few years.

Present small business computer systems utilize between 16K bytes for the smallest system and up to approximately 256K bytes for systems at the upper size range. Memories are typically organized corresponding to the word length of the processor, either an 8-bit, 16-bit or 32-bit word. We do not expect any significant changes with regard to the word length.

There has been a trend, however, towards increased data security. Memories increasingly have been equipped either with parity bits for each word or with redundancy bits in order to implement error correcting codes. Since the decreasing cost of semiconductor memory not only reduces the price penalty for

such features but also encourages users to order much larger memory systems per installation, error correcting capabilities will be an accepted feature of small business computer systems in the near future. Even now some manufacturers, such as Texas Instruments, recommend error correction with any minicomputer having 40K bytes or more.

Error correction usually requires 22 bits if the system is oriented towards word lengths of 16 bits, and approximately 40 bits for systems organized around 32-bit words. Error correction cannot be implemented in an economic way per byte in byte-oriented memories. The usual method of error correction in this case is to design a memory with 16-bit word lengths and use it in such a way that individual bytes can be retrieved.

There is some evidence that future generations of memory chips exceeding the density of the present 16K-bit chips will have to include error correction code and hardware within each chip. If this becomes the accepted configuration of the future, it is probable that no additional error correction has to be included in the memory system for most applications.

The expected continued downtrend of semiconductor memory cost throughout the decade makes it worthwhile to speculate on the size of the main memory system included with future small business computers. Currently, one Mbyte of memory with sufficient speed of operation costs approximately $8,000 to $10,000 (printed circuit board only) in OEM quantities. On the other hand, an emerging new generation of small Winchester hard disk drives offers 4 Mbytes for between $1,000 and $1,500, also in OEM quantities. With semiconductor memory systems, we expect a sustained downtrend of approximately 30% per year over many years, due to increased density, advanced packaging schemes and higher level integration of supporting circuits. Hard disk technology is also expected to offer higher capacities and performance as well as lower costs. In the future, however, changes will not be as dramatic.

It may be expected that memory systems of between 0.5 Mbytes and up to 2 Mbytes will become economically feasible around 1985 or 1986, even for the

smaller size range of business computer systems. In most cases, however, there will be a considerable price difference between electromechanical magnetic storage devices and semiconductor memory whenever several Mbytes capacity is required. We do not want to exclude the possibility that this price difference might disappear towards the end of the decade.

Replacement of electromechanical mass storage devices by semiconductor memory might have other advantages. One such advantage is access speed. The only immediate advantage for access speeds higher than presently offered with hard disks appears to be in high performance data base and file applications. At present, small business computer systems are not used for this purpose. Mass storage devices are sufficient for smaller data bases, software storage, and certain types of temporary data storage. We do not want to exclude the possibility, however, that larger data bases, which have to be accessed by multiple users, might be included within the capabilities of the mid-range of small business computer systems in the future. In this case, semiconductor memory systems large enough to contain either the complete data base or certain large sections of it would be a distinct advantage. Because of the importance of the data base and file management/access operation, we have covered such system features in a separate section of this chapter.

Read Only Memory (ROM)

We see ROM or PROM as a very economical way of storing system application software in small business computer systems. Modules of software are contained in individual chips or chip sets, which may be inserted into sockets on printed circuit boards. Other packaging schemes are possible with specially designed modules containing more than one semiconductor chip. The advantage here is the nonvolatility of the memory content when compared with storage in RAM, and a lower price per stored byte. We believe that eventually even in slightly larger business computer installations a software architecture might develop where many routines are basic to all business applications. All utility programs, basic input/output routines, and basic accounting routines will be stored in ROM modules, while the backbone of the application package contains all application oriented program segments and calls these basic routines on demand.

The backbone of the application package may be stored in ROM in small systems or contained on disk or floppy disk and read into RAM in larger systems.

Processors

In the section dealing with LSI technology, we pointed out that the upcoming generation of 16-bit microprocessors, represented by the Zilog Z80, the Intel 8086 and the Motorola 68000, will perform equivalently to present medium range minicomputer processors. In addition, the Motorola 68000 offers internal 32-bit structure, hardware multiply/divide, hardware floating point capability and internal hardware to support multiprogramming. Such capabilities equal or exceed those currently used in even the upper system sizes of small business computer systems. On the other hand, it is practically certain that microprocessors with even more complex internal architecture, higher speed and additional features will become available within the next few years. The cost of a CPU, including all necessary interfaces, supporting chips, bus structure, etc., implemented with any of these newer 16-bit microprocessors, will be a relatively insignificant portion of the total system cost, although it might be several times as high as the cost of a current small 8080-based CPU. We therefore believe that new capabilities which might become available, rather than CPU cost trends, should be of interest to us.

We pointed out that processor architectures are possible which facilitate application software portability between different types of machines. We also explained that Western Digital Corporation's "PASCAL" micro-engine is a step in this direction. Further, the generally accepted trend towards relieving the main processor of routine operations associated with serving peripherals, accessing mask storage devices, etc. is well established and will continue in the future. Specialized microprocessors in LSI technology are currently available in many forms serving as floppy or hard disk controllers, printer controllers, direct memory access controllers, or to relieve the main processor of tasks necessary for various types of memory management. Additionally, everything connected with implementing data communications, including elaborate protocols and data verification, are customarily delegated to specialized processors or even dedicated LSI chip sets.

There is, however, one further trend which might prove to be of importance in the future. Several semiconductor companies have recently announced specialized arithmetic chips which are meant to complement the capabilities of a microprocessor for scientific and technological applications. Such chips, which may be regarded as specialized microprocessors, implement certain functions such as fully transform, regulation of trigonometric functions, etc. more efficiently than possible in a general purpose microprocessor. Thus, average throughput may be increased considerably by the use of this auxiliary processor in applications where these types of calculations occur often enough. In the same way, the processor may be relieved of certain time consuming tasks and business applications. These might be handling of long character strings, sorting routines and other utility tasks executed in main memory. It appears possible to use a standard microprocessor, equipped with special software or firmware, in order to execute these functions independent from, but under the supervision of, the main processor.

Mass Storage Devices

Tapes and tape cassettes have been largely replaced by the popular floppy disk in many of the currently offered small business computer systems. At present and in the future, many applications within the smaller size ranges of systems can be entirely covered with a combination of floppy disk drives and main memory.

There is a large gap in cost between floppy disk units and traditional hard disks. It appears that the needs of all contemplated small business system configurations for the next decade can be covered with any of the upcoming devices of this type, which range from capacities of approximately 4 Mbytes to around 30 Mbytes. Future trends are expected to offer a wider range of capacities, produce access time, as well as combinations of fixed and removable disk cartridges.

At present it appears that a combination of a fixed disk of this type with one of several floppy disks which serve as a combination of input/output/random access device is entirely sufficient for any contemplated future system. However, the system having one or more fixed disk drives might not necessarily need the random access capability of the floppy. Further, a set of several diskettes might be required to load one Winchester drive oi more than the minimum capacity. We believe, therefore, that there is likely to be some return to use of tape or tape cassette drives for these applications. For example, the larger 3M cassette would be capable of holding enough information to load more than one 8-inch Winchester drive. (See Section E for further information on mass memory devices.)

Printers

We have covered the cost and technology trends of printers under Section F of this chapter. At present, a line printer of up to approximately 300 lines per minute, 132 characters per line and capable of handling paper and forms of all widths may be considered the standard output device. Character printers are usually confined to word processing and other operations requiring exceptional output quality. Careful analysis of the application is required in order to specify a particular printer.

One development, however, might be of importance after 1985. High performance non-impact printers, usually based on technologies derived from modern office copiers, are currently being introduced in large EDP installations. We expect that printers based on similar technologies will become gradually available with downgraded throughput and at very much lower prices. Current experience with these printers shows that they have the following distinct advantages:

- They generate very low noise levels, a trait especially valuable in the office environment.
- Although these printers cannot print multiple copies, they usually can print the same page several times in sequence in the same time an impact printer prints one page. Thus, expensive multiple forms are no longer necessary.

- These printers have certain graphic capabilities. If combined with the right software and controller, such printers are capable of not only printing the desired output information onto an existing form but of printing the form itself at the same time at no penalty of speed or cost. Thus, it might become feasible to eliminate any need to print and stock the necessary forms.

Data Communications Capabilities

We believe that with the more general acceptance of small business computer systems, there will be an increasing need for data communications. First, in many situations small business systems will feature multiple work stations which have to communicate with the hub of the system. Further, independent small business systems may have to communicate with either larger computer installations in a corporate headquarters, with centralized data banks or even with service bureaus providing certain business services.

We believe that any future small business system will take a modular approach towards the incorporation of data communications. A variety of self-contained interfaces, possibly in printed circuit board form, will be available in order to cover the necessary protocols and procedures. Such data communication interfaces will be based on separate microprocessors, will operate under the general supervision of the main processor but will, in most cases, use direct memory access, not requiring any action by the main processor in order to handle the data flow.

We foresee the following general trends in data communications:

- There will be an increasing integration of voice and data within PABX systems and private corporate networks, requiring computer systems and work stations to interface with them.

- Asynchronous, character-oriented transmission will be replaced by advanced synchronous schemes like SDLC, HDLC, and others.
- The upcoming digital integrated telephone network, in the long run, will offer transmission capabilities of considerably higher bit rates than previously available. Therefore, systems are likely to include capabilities to telecommunicate at much higher speed.
- Packet switching will continue to gain in penetration in many countries, although not to the extent previously forecast by many experts. However, packet switching interfaces might be necessary and available in this context for certain applications of small business systems.

5. Trends and System Configurations

Presently, a small business computer consists of the processor, main memory, associated mass memory and removable media devices with an attached operator work station. This work station features in almost all cases a CRT console, an alphanumeric keyboard, usually with attached numeric keypad, as well as some kind of output printer.

The upcoming generation of new business computer systems also includes the capability to support additional detached work stations. These work stations communicate with the main unit through either dedicated lines or through a PABX. They also consist of a CRT console with a keyboard as a minimum configuration Usually, some additional memory is included and the operator is offered a certain amount of editing and formatting capability.

We do not anticipate that the general configuration of future systems will be much different from the one just described. There will certainly be a trend towards the multi-work station system. Also, it can be expected that the customary CRT display will be replaced by some other technology, possibly a flat liquid crystal display unit, by the end of this century.

The development which is most likely to occur in certain applications is an increase of capabilities of the detached work station. In the same way as experienced with computer terminals, it is most likely that the present type of work station with only limited capabilities will evolve along the lines of the so-called "intelligent" computer terminal. In this case, all the additional features discussed under the section dealing with intelligent terminals might be incorporated into such a work station, including local programming, possibly a floppy disk or tape cassette for local off-line storage and several other features. Evolution of the present work station into this kind of configuration might even eliminate the need for a full time data communications connection to the main system. In this case, a switched connection to an existing or future PABX, capable of supporting data traffic, could be very cost saving. Data calls between the work station and the central system do not have to be dialed by the operator; they can quite well be initiated by the central system or by the work station itself.

In advanced, distributed systems, it is a question whether one printer will be shared by all work stations or whether multiple printers will be installed. We believe that this is a question which cannot be answered in general terms but that each application has to be analyzed separately. Cost of printers at the time the decision has to be made, physical distribution of the work stations (whether they are all in the same building or distributed throughout a metropolitan area, etc.) and many other factors influence the decision. However, advanced printer technology might well reach the point where versatile and relatively high performance printers become so inexpensive that one such printer can be included with each work station.

Future Outlook

Some insight into the potential of computer technology towards the latter part of this decade might be gained from some of the futuristic research projects being conducted by major corporations involved in this field. One of these projects is the "Dynabook" of the Xerox Scientific Laboratories. The purpose of this project is to develop some knowledge about the potential of computer technology for future personal and home computers and their application to everyday tasks as well as to education and the handling of personal information.

This advanced project, which is conducted at the company's Palo Alto Research Center, is to provide the power of the medium sized computer in a package the size of one encyclopedia volume. The Dynabook is based on the Motorola 68000 computer, bubble memory and low cost semiconductor memory. The total memory capacity is 16 Mbytes. Provisions for input and output consist of a thin solid state display, capable of not only alphanumeric but some degree of graphic output plus a small full alphanumeric keyboard. The system is organized around the eight separate tasks being supported by the 68000 architecture. This allows allocation of an average of 2 Mbytes to each task.

It is not reported what the applications are which the Laboratory studied in detail, but evidently they include calculator operation, personal data base processing, storage of memos, reminders and processing of schedules, personal text processing, as well as games and encyclopedia-related functions.

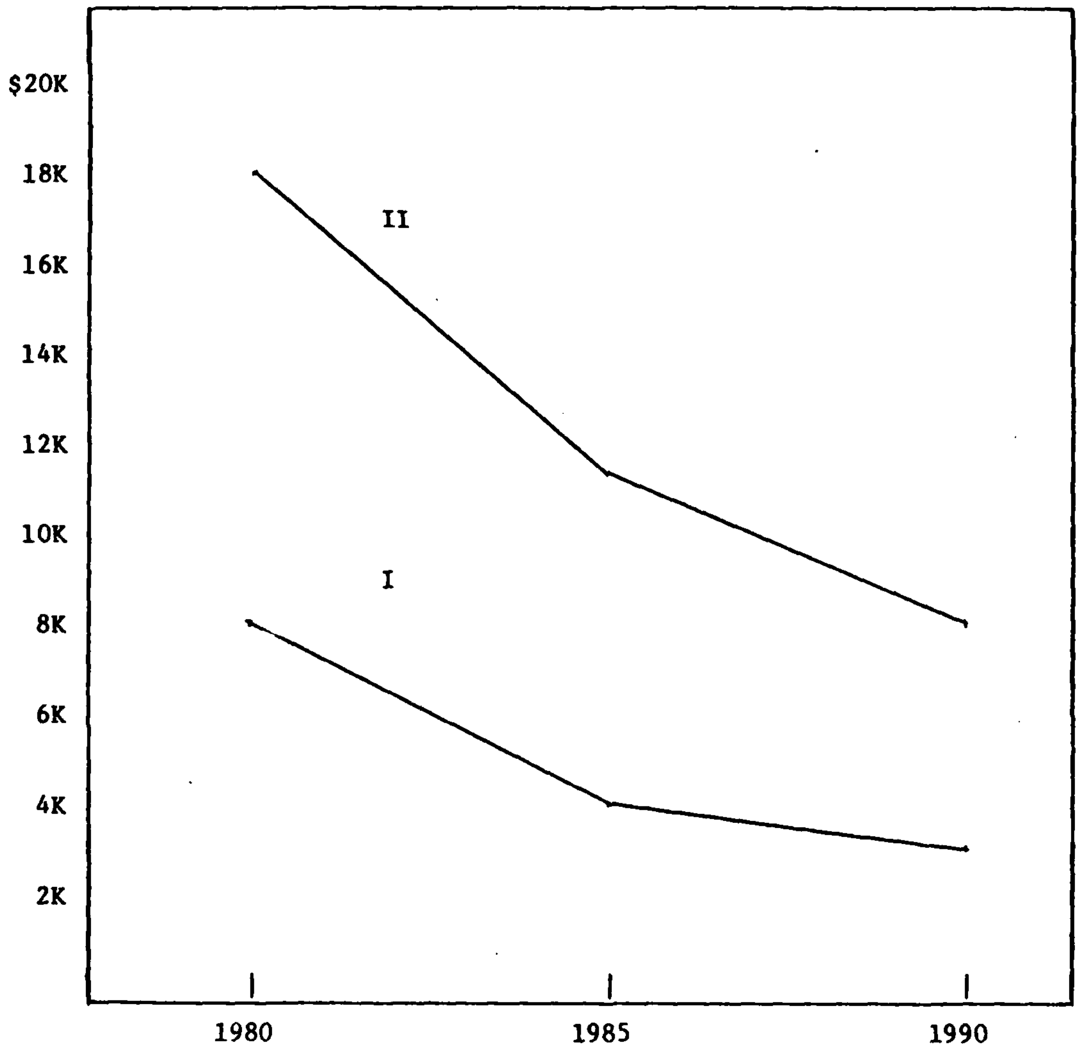
Projects of this kind are usually not aimed at the development of a product for the immediate future. However, they would not be undertaken if their sponaors did not believe that the capabilities built into the experiment would not become economically available, possibly with a slightly different technology, within a certain period of time.

6. Cost Models

The following Exhibit VIII-2 presents our forecast of the cost of future small business systems. We have compiled cost figures for two size ranges. The smaller one would presently be regarded as being at the lower end, while the larger one would presently fit into the mid-range of available small business systems.

The decreasing cost of system components, particularly semiconductor memory and mass memory, is likely to result in the inclusion of larger storage capabilities within future systems. Our models therefore assume an increasing amount of main memory and mass memory, as indicated in the Exhibit.

COST FORECAST OF SMALL BUSINESS SYSTEMS



I. 8/16-bit CPU; 32K bytes memory, increasing to 256K bytes in 1990; 12-inch CRT console; data communications interface; 180 cps printer; two 8-inch floppy disks.

II. 16/32-bit CPU; 128K bytes of memory, increasing to 1 Mbyte in 1990; 12-inch CRT console; data communications interface; 150/300 cps printer; two 8-inch floppy disks; one 8-inch Winchester with backup.

EXHIBIT VIII-2

E. MASS MEMORY DEVICES

Mass memory devices in data processing installations as well as in intelligent terminals are used for two purposes. One is the off-line storage of software as a backup for software used in main memory or for software not currently in use. The second application is the intermediate or long term storage of data, particularly that of structured data files.

Small business computer systems, as well as intelligent terminals, currently use floppy disks for the purpose of storing data. These disks have penetrated into application areas formerly occupied by a large variety of tape cassettes and to some degree, inexpensive 7- or 9-track magnetic tape drives. More recently, small Winchester hard disk drives have appeared on the scene. These units do not offer a removable medium but have considerably lower access time than floppy disks and a larger and wider range of storage capacity.

While these two classes of units have a wide range of applications in very small to medium-sized data processing installations, they certainly have limitations in terms of total storage capacity and access time as well as other parameters. New devices are expected to become available towards the 1980s which might be expected to satisfy at least some of these needs.

1. Floppy Disk Drives

The 8-inch floppy disk drive has emerged as the major off-line storage medium for minicomputers and small business systems. The current top-of-the-line 8-inch unit of the so-called double density, double-sided variety, stores approximately 1.2 Mbytes of information on one diskette. A smaller size called a "mini-floppy" stores approximately 110,000 characters in single density or 220,000 in double density per side and is intended for application in intelligent terminals and in very small microcomputer systems.

The acceptance of floppy disk technology has been surprising, with one of the main manufacturers currently achieving an output of 2,000 drives per day.

Floppy disk drives are used mainly for two reasons. First, they offer true random-access capabilities at a very moderate price. Secondly, the diskette constitutes a very inexpensive removable medium which is very well suited to the office environment for off-line storage of data and software, as well as mailing.

Among the disadvantages of the floppy disk technology are the relatively long average access time which is in the order of magnitude of 0.25 seconds. However, the upcoming technology of miniaturized Winchester hard disk units offers a faster alternative for this kind of application. However, even in systems featuring six Winchester drive disk units, floppy disks will be still very valuable as input and output devices for data and software for random access capabilities.

During the first half of the 1980s, we expect that the current trend towards increase of recording density, especially on the 8-inch floppy disk, will increase to at least two and possibly to five megabytes per double-sided diskette. This density appears to be technically feasible, at least with drive mechanisms of improved mechanical performance and would be very valuable in applications where data on small Winchester drives have to be backed up for security.

While there will be a need for off-line storage media of increased per unit capacity during those years, we believe that they will have to be met with a differently designed unit. This could be a disk unit with a high-density storage medium of a different mechanical configuration, which appears to be technically possible, or a radically different design. In any case, we believe that during the latter part of the 1980s, there will be a need for a removable storage medium suitable for the emerging small computer environment which is capable of storing between 10 megabytes and 20 megabytes of information.

The design of floppy disk units has reached a remarkable degree of maturity. Currently, 8-inch drives cost around $300 and 5 1/4-inch drives around $200 in OEM quantities. Since the read/write head is the most expensive component of these drives, the inclusion of a second head in the design of a double-sided drive increases the price by 20% to 25%.

We believe that it is unlikely that these prices will drop any lower in the future. However, we believe that increasing sophistication of design and production engineering is likely to result in the absorption of the additional cost involved in redesigning the drive for capacities up to 3 to 5 Mbytes total. Further, it is generally expected that cost reducing improvements in the read/write head design are possible.

2. Small Winchester Drives

Very recently, a new random access storage medium for the mini- and microcomputer installation has been developed. An 8-inch Winchester drive is an evolutionary successor of the 14-inch drive, which emerged from the Winchester-type technology used for some years in disk drives for large computer installations.

Eight-inch Winchester drives use one or more hard recording surfaces and read/write "fly" at considerably higher altitudes than traditional tape drives. This fact combined with other design improvements, has totally eliminated the danger of head crash damage. Heads are actually allowed to crash each time the drive is stopped without causing any damage to the recording service. Recording medium and heads are enclosed in a sealed compartment which includes provisions for filtering the air.

A variety of designs with various capacities and price ranges is currently offered with a total capacity of approximately 5 megabytes while multi-surface units go up to 24 megabytes and more.

An important consideration in the layout of a Winchester disk unit is the trade-off between required uniformity of the recording surface and density of recording. Relatively low density allows the designer to employ an economical variety of recording medium. High density recording, usually necessary in units achieving large storage capacity, makes it necessary to use a recording medium with a few defects which generally means higher quality and higher cost. The higher cost of the quality medium is largely caused by yield problems in

the manufacturing process. Future improvements might lower the cost and increase the storage capacity per recording surface in the less expensive range of the product lines.

Reliability and ruggedness of 8-inch Winchester drives is superior to those achieved with traditional hard disk drives. Typical MTBF of 10,000 hours are currently being achieved. Contamination of the air is no problem, since recording surface and heads are sealed and impurities from the enclosed air are automatically removed. Further, these drives are quite independent of vibrations (this is supported by submounts), and other mechanical influences.

Future Technology Trends

Eight-inch Winchester drives have just been introduced and are very well accepted for incorporation into small business systems. We expect that for at least several years, manufacturers will tend to solidify this position and slowly improve the performance of their products. Drives of this size, however, have great potential for improvement. Several controlled positioning mechanisms and 8-inch Winchester drives currently have between 200 and 500 tracks per inch; step or motor mechanisms have lower densities. High-performance drives employ byte densities of 8,500 per inch. It is estimated that densities as high as 1,000 tracks per inch as well as considerably higher bit densities are achievable in high performance units. We believe that Winchester drives featuring between one and four recording surfaces per drive are quite capable of covering capacities of up to at least 100 megabytes at the end of the decade.

In addition to 8-inch drives, a variety of different diameters are likely to appear. A 5 1/4-inch mini-Winchester has already been announced by one manufacturer for application in smaller computer systems. This unit offers an unformatted storage capacity of approximately 6 megabytes.

Whether or not Winchester drives with larger disk sizes will experience a revival depends on the need perceived for storage capacities well above 50 megabytes in the future.

Currently, a 5 Mbyte Winchester costs about $800 to $1,000 in large OEM quantities while the 25 Mbyte variety costs approximately $2,300 to $2,800. In 1990, it is likely that the low-end 8-inch Winchester drive will cost $600 to $800 and will store an access of 10 megabytes while top-of-the-line models will be capable of storing 100 to 200 megabytes and cost between $2,000 and $2,500.

3. Controllers for Floppy Disk and Winchester Drives

Very recently, a variety of high level, configured circuits have emerged which are capable of performing most controller functions for either floppy disk or Winchester drives in one chip. This includes all logic control functions as well as general interfacing functions, device selection, modulation and demodulation and many others. Such chips need to be complemented with a minimum of discrete circuits and simple logic functions in order to interface between one and four such drives with a small computer. However, in such a configuration, extensive software is still needed in the computer in order to actually use the device. This software includes a device driver, extensive formatting functions and others. This puts a considerable burden on the CPU, but is usually a feasible method of interfacing devices of this kind with very small computers or intelligent terminals.

If useful throughput of the CPU is of concern, as it is in most small business applications, more functions are customarily incorporated into the device controller and presently implemented into the manufacture of hardware and software. The complexity of the device controller is then raised from the one chip level to the one printed circuit board level with cost increasing to several hundred dollars.

In 1990, it is expected that complete peripheral chips for the implementation of all disk controller and formatting functions will be available as auxiliary chips to the more powerful microcomputer families. These chips will contain their own software (ROM) and operating memory and will cost in the range of $10

to $30 at that time. Such chips will require only few additional components and are likely to bring the cost of the complete device controller, inclusive of formatter, down to the range of $100 or less.

4. Expected New Technologies

Magnetic Bubble Memory

Magnetic bubble memory is currently not accepted as well as predicted a few years ago. This is due to the fact that manufacturers have experienced difficulties in achieving high yields and in meeting delivery schedules. On the other hand, rapidly decreasing prices for semiconductor RAM chips as well as the 8-inch Winchester drive technology have made it questionable whether bubble memory will provide the best low-cost, long-range solution to the requirements for nonvolatile backup memory.

We predict that bubble memory will capture new application areas, but grow rather slowly during the 1980s. It will not provide the generally accepted solution for large bulk storage requirements, but rather be consigned to specialized operating environments where either electromechanical storage devices or semiconductor memory are not easily adapted. Shipboard use may well be one such application.

Very recently, a new large capacity tape cartridge with sequential storage mode has been introduced: the "streaming tape drive." This device has been designed specifically for the purpose of backing up file memories based on 8-inch Winchester units and can store up to approximately 35 Mbytes of data. Currently, this device is offered at a price of around $8,500.

We believe that it is too early to judge the trends for success of this particular device. However, it is very likely that additional devices will appear on the market during the next few years which will be based on a variety of design principles but will have in common the use of improved magnetic recording media and high-density sequential recording schemes. These devices will be designed for the purpose of storing the contents of either an 8-inch

Winchester drive or of a large block of semiconductor memory in one piece for possible retrieval at a later time. There will be little need for random access and search modes.

Success of devices of this type will depend on their reliability, on the cost of the removable storage medium itself and the ease with which the storage medium and the device can be handled by untrained office personnel.

Optical Recording Mass Storage Devices

Mass storage devices of very large capacities based on Laser beam recording and retrieval technology have been announced from time to time and have occasionally been used in large computer installations in the past.

Developments aiming at products suitable for the home use video disk market have the potential of generating the "spin-off" developments suitable for bulk storage in smaller computer systems. A device of this type has been demonstrated by the Philips Research Laboratory in Holland. While it is not quite clear what the plans of Philips are regarding the introduction of the finished product along these lines, we believe that devices of this general class are likey to fit the data processing environment during the latter part of the 1980s. At that time, there will be a need for supporting a large number of data files much larger than can be accommodated with small magnetic disk files. Whether or not optical recording devices like the one demonstrated by Philips will actually be available on the market will depend largely on the progress being made during the same time with magnetic recording technology as well as by the need for large files in a large portion of small to medium sized computer installations.

The Philips device uses a semiconductor Laser to record and read on a revolving disk. At present, a layer of tellurium-based metal is used for the disk. Modulated light of sufficient power emitted from the Laser generates individual pits or holes in the surface of this disk which later can be detected optically, using the same Laser at a lower power level. For the unit demonstrated by Philips, a disk with a useful outer radius of 14 centimeters and useful inner radius of 7 centimeters is used. The disk uses 46 tracks. In

order to simplify the mechanical design of the drive itself, the recording surface was pregrooved in a spiral-like fashion like a traditional audio recording disk. The unit demonstrated included error correction circuitry and was capable of storing 1,000 megabytes of user accessible information on one side of the disk.

Average access time of the unit was 0.25 seconds at 2.5 revolutions per second of the disk. However, considerably faster access has been demonstrated with the disk rotating at 25 revolutions per second. Further, data transfer rates of 1 Mbps and higher have been achieved.

It is estimated that this technology is capable of storing up to at least 10,000 Mbytes on one surface. However, when comparing this technology with storage on moving magnetic media, it has to be taken into account that Laser storage devices cannot erase the recorded information. They rather have to depend on the recording of updated records from previously blank space on the disk and obliterating the old address. Therefore, depending on the exact application environment, up to several times the storage capacity may be required on an optical recording device than would be sufficient with a magnetic disk drive for the same purpose.

Although the exact configuration of the unit demonstrated by Philips is most likely not the configuration in which similar products might first appear on the market, we believe that we can draw some conclusions from properties of this unit:

- Compact Laser-written optical storage, applicable to small or large computer systems, is technically feasible.
- The use of semiconductor Lasers considerably reduces the cost of the recording functions.
- Use of a pregrooved recording medium considerably reduces the complexity and cost of head positioning functions when compared with the more traditional approach not using grooves on the recording surface.

- Storage capacities of between 1,000 and 10,000 Mbytes in a unit not much bigger than the present high capacity 8-inch Winchester disk drive appear to be feasible.

Judging from the complexity of the unit demonstrated by Philips, and by developments going on with several different manufacturers, we would anticipate that devices of this type have the potential of being manufactured at costs which are in the same order of magnitude of those expected for typical 8-inch Winchester drives in the mid- to late-1980s. The main question, however, is whether or not there will be enough demand for such units to support high volume manufacturing during this time frame.

Cost for such an optical storage mechanism is likely to be in the $10,000 to $20,000 range in the early 1990s, storing up to 1,000 Megabytes. The basic disks may cost $15 to $20 each.

The use of this type of storage for personnel and pay files could be quite attractive since a permanent record of all pay-related information would be maintained.

F. LINE AND PAGE PRINTERS

In the following section, we will deal with three main technologies: impact printers using either a moving chain or moving belt; electrostatic printers; Laser printers. Printers of all three technologies are likely to be useful in applications aboard ship using either minicomputers or microcomputers as processors. All three technologies are also used for installations requiring a higher throughput.

1. Chain and Belt Printers

Smaller business computers are typically using this type of device at printing speeds of 150, 300 or 600 lines per minute (lpm). High performance devices are capable of printing 1,000 to 1,200 lpm.

This technology is characterized by a chain belt or rubber band carrying one or more complete character sets which move at constant speeds in front of the paper in the direction of the line to be printed. A set of hammers, typically one for each print position, is located behind the paper. Individual hammers are activated electronically at the moment the appropriate character passes under the hammer location.

Typically, line printers of this type are relatively complex mechanical devices, using a high number of individual mechanical parts. Electronic control of the printing mechanism, however, has recently become less costly due to the incorporation of microprocessor technology.

This class of devices currently includes not only line printers for use on minicomputers but also such devices as the General Electric Terminet printing time-sharing terminal, which uses a printing belt and the teletype data speed 40 output chain printer capable of printing 300 lpm. Interest in line printers of 150 and 300 lpm, however, has cooled off recently to some degree, because of advances made in wire dot matrix serial printers (see next section) which have become capable of printing at approximately the same speeds and are available at lower cost.

It appears that some new manufacturers, among them Nippon Electric Corporation, are currently active in designing new products of this type. For example, a recently announced NEC printer uses an etched continuous stainless steel loop as a printing belt. The number of the costly print hammer mechanisms is reduced to one hammer for every four print positions, with the hammers being shifted into different positions by a separate mechanism. The whole printer is designed like an office machine. Control is entirely by a microprocessor. Printing speeds range between 160 and 600 lpm. Further, simple graphic output is included.

We believe that mechanisms of this type constitute a trend which will lead to production of more devices of this type for applications in the distributed processing environment towards the end of the 1980s. Cost reduction of complex electromechanical devices like chain and belt printers is difficult to achieve. However, we believe that intelligent designs for high volume production are likely to result in a price range of such printers of between $2,000 and $3,000 in 1990.

2. Electrostatic Printers

These printers, originally developed for high speed printing on large mainframe computers, are also available in slow and less costly versions for use with minicomputer installations. The principle used is based on the use of special electrostatic paper which is coated to hold an electrostatic charge. Charges are deposited on the paper from a dense row of electrodes over which the paper is moved at constant speed. Charging voltages on individual electrodes are controlled according to the desired print pattern. Afterwards, the deposited electrostatic charge image on the paper is developed with a toner similar to the process used in copiers using specially coated papers.

Printers of this type are currently offered at speeds ranging from 300 lpm to 18,000 lpm with prices ranging from $5,000 to more than $165,000. If manufacturers see a wide market for this type of device, we are convinced that electrostatic printers capable of printing at 300 to 600 lpm could be made available within the next five years at prices between $1,500 and $2,500.

The main disadvantage of this type of printer is the requirement for special paper. Typically, the electrostatic paper with special coating costs around three times as much as ordinary paper. Therefore, we believe it doubtful that this type of device will be of much significance for the applications we are discussing in this report.

The main advantage of electrostatic printers is the capability to include not only graphics but complete forms in the printout without reducing the throughput. This facility is also available with the Laser beam printers which are discussed below.

3. Laser Beam Xerographic Printers

The electrostatic printer may be considered a derivative of the coated paper copier; the Laser beam printer is a derivative of the plain paper copier and uses the same Xerographic process. Instead of projecting the image of an original to be copied on a photoconductor, a system of moving rotating mirrors projects a Laser beam onto the photoconductor in such a way that it is scanned like a television screen. While the Laser beam is modulated in intensity with the information to be printed, the same pattern of changing charge pattern is generated on the photoconductor as is in the plain paper copier. Application of toner, as well as transfer from the photoconductor intermediate storage to the final paper page and development of the image, are exactly the same as in the copying machine.

Electronic circuitry is necessary in order to accept the computer output in alphanumeric form and convert it into the analog signal necessary to modulate the Laser beam. Such circuitry is available with the capability to select one out of several electronically-stored type fonts in order to generate a high quality page with the appearance of a typewritten or printed page. Further, electronically-stored forms can be superimposed without adverse effects on the throughput of the printer. Thus, the need for expensive preprinted forms, which have to be constantly kept in stock, is eliminated.

Laser-Xerographic printers of this class have been available in the past only for higher throughput applications in connection with large mainframe computers at prices in the multi-hundred thousand dollar range. More recently, however, such printers have become available in the range of $8,000 to $15,000 capable of producing between seven and twenty pages per minute. Notably, a device recently introduced by Cannon in Japan, currently offered in the United States for $5,000 (OEM without electronic interface), appears to constitute an interesting trend. The Cannon unit is capable of printing ten pages per minute and offers an example of the printed page good enough for high quality output of textual material suitable for further printing. Electronic interfaces capable of generating only alphanumeric output but offering a selection of type fonts and stored forms are still quite expensive. We believe that microprocessor technology will bring the cost of such interfaces down to the range of $500 to $1,200 in 1990, provided that Laser-Xerographic printers become widely accepted and interfaces are required in large enough volumes. The price of the printer, if manufactured in high enough volumes, is estimated to be around $2,500 to $4,000 in 1990.

One important drawback of the Laser-Xerographic printer as currently designed is the requirement for relatively frequent maintenance. In this respect, this type of device shows its close relationship to the Xerographic copying machine which exhibits this same drawback.

4. Future Significance Within the United States' Navy Pay System

While line printers of the chain or belt variety are likely to retain or possibly increase their market share in the small computer data processing environment of the next decade, Xerographic Laser printers are still expected to grow in performance, reliability and general acceptance over the next ten years. Although they cannot print multiple copies, they are likely fast enough to print several copies of the same page sequentially, if more than one copy is required. The main advantages are the relatively high quality of output which makes them suitable for word processing, and the capability to generate a variety of special forms on plain paper, eliminating the need to stock these forms at the location of the printer. We can see that this would be of particular interest aboard ship.

G. SERIAL PRINTERS

The technology of serial printers has evolved from the traditional teletype machine to reach a considerable degree of maturity. However, some technological improvements are anticipated to occur during the decade of the 1980s.

Technology of serial printers may be divided into the following groups:

- Impact printers
- Formed-character printers
- Dot-matrix printers
- Non-impact printers
- Thermal printers
- Ink jet printers
- Printers using electrosensitive paper

For the purpose of this survey, we define a serial printer as one which completely prints out one character at a time before proceeding to the next character on the same line. There has been some confusion about the distinction between character and line printers. This stems from the fact that certain printers, some Centronics models, for example, were originally character printers, but for reasons of increased printing speeds, are equipped with a line-wide character buffer which has to be filled first before the carriage starts to move across the page, printing the whole line serially without interruption. Other models of the same manufacturer use a printing mechanism which looks almost identical but prints a character whenever the one-character buffer is filled and then stops at the next print position and waits for the next character. True line printers, in comparison, accept a full print line into a line-wide buffer but then proceed to either print the characters in a line at random, or portions of all characters of the print line simultaneously.

Whenever output from a minicomputer or microcomputer is to be printed, the serial printers print a line at a time, reversing direction of carriage movement between subsequent lines in order to eliminate the need for carriage return.

1. Impact Printers

In addition to the traditional teletype machines which have served as the standard computer terminal for a long time, we now have a wide variety of other printing mechanisms using formed characters. Among those are mechanisms using "golf ball" print heads (IBM Selectric and others), "thimble" print heads (Nippon Electric), daisy wheels (Diablo, Qume, Qyx-Exxon) and other related devices. These printers are characterized by their high quality typewriter-like printing quality. They usually offer interchangeable print heads which allows selection of the proper type font for each application. However, their printing speed is usually only in the 30 to 70 characters per second (cps) range.

These formed-character printers currently have their main application in word processors, intelligent typewriters and typewriter replacements. Their printing speed is usually below that of a less expensive dot-matrix printer. The fastest presently available printer of this type is offered by Qume, and achieved its speed of 75 cps only by employing two separate print heads. Also, formed-character printers tend to be mechanically complex and are usually more expensive than dot-matrix serial printers. We do not expect that considerable improvement will be seen with this general group of devices through the 1980s. It is even possible that technological advances of dot-matrix printing technology or even of certain types of non-impact printing technology will move in such a direction as to yield devices capable of the same high quality of output currently obtained only from formed character printers. If this happens, we will see gradual disappearance of formed character printers during the 1980s.

Dot-Matrix Printers

This type of device has gained considerable acceptance as a general purpose output printer for minicomputer and microcomputer systems. Currently, printing speeds up to 180/250 cps are quite common; the fastest units achieve up to 900 cps. Print quality is sufficient for general purpose computer output, and several character sets are generally offered.

Currently, in the lower speed range of 120/180 cps, such devices are offered between $1,500 and $2,000, capable of printing 132 columns and including tractor

feed mechanism, while 80 column-wide printers capable of printing either on roll paper or individual sheets are in the range of $500 to $900. Generally, reliability of these devices is much better than that of most formed-character printers. The printing principle used, individually controlled printing wires each printing a dot at a time while moving across the paper, is capable of improvement in different directions. We expect that this type of printer will be used even more widely during the latter part of the decade and will exhibit improvements in the following areas:

- Further decline of price, particularly for the higher performance devices, due to increased manufacturing volume
- Increased printing speed, at least for the middle-of-the-line devices
- Increased printing quality, making it possible to use dot-matrix printers as output devices for word processors or as installations for mixed data processing and word processing

Reduction of dot size and increased of number of dots per character certainly would make it possible to achieve any desired print quality in a wide variety of type fonts. However, limits to miniaturization of character components as well as complexity in resulting costs sets certain limits in this respect. Currently, one device manufactured by Florida Data offers a choice of two operating modes. The normal mode prints 600 cps, using a 7 x 8 wire-dot-matrix. For high quality, the device is slowed down to 300 cps and makes two passes on each line, filling in a denser 16 x 16 matrix. Due to the two passes per line, the actual net printing speed is only 150 cps. The print quality, however, is almost indistinguishable from that of high quality chain printers and is already approaching the quality of standard typewriter output.

The two-pass approach requires a high degree of repeatability between the two subsequent passes of printing. We understand that other manufacturers of

dot-matrix printers are looking at different solutions for the same problem. We believe, however, that towards the end of the 1980s, there will be several such devices capable of forming at the speed of at least several hundred characters per second for general purpose computer output operation and up to 200 cps involved for document printing, yielding a printing quality sufficient for correspondence and conventional use.

While only moderate cost reductions of the basic wire dot-matrix printing mechanism can be expected, due to its high content of labor-intensive mechanical precision parts, it is likely that subsequent generations of mechanisms of this type will be available at approximately the same end-user price as today's most popular low to medium speed printers.

Many of the available dot-matrix printers print a full line using a continuously moving carriage. In order to increase the net printing speed, subsequent lines are printed with reverse direction of carriage movement, thus eliminating the delay for returning the carriage. Net printing speed in characters per second, however, is at a maximum only if all lines are filled with characters, since the time required for each pass of the carriage across the page is independent of the actual number of characters printed. It is interesting to note that certain printers of this type which offer a choice of proportional spacing characters achieve a higher throughput of characters printed per second, since proportional spacing increases the average density of characters.

Special Purpose Dot-Matrix Printers

Distinct from the class of general purpose computer output printers using dot-matrix technology, there are special purpose devices such as those used in modern electronic cash registers, ticket printers, desk-top calculators, and other similar devices. Here, wire dot-matrix printing technology is employed for two reasons. First, it allows the use of inexpensive plain roll paper and, in certain applications, satisfies the need for printing multiple carbon copies.

Currently, this type of special-purpose printer is gaining rapidly in popularity. We believe that this trend will continue at least until the second half of the 1980s. This type of device, however, is usually sold to original equipment manufacturers and not to end users. Further, it is usually engineered to fit special and high volume applications. It is, therefore, not easy to make predictions about future capabilities, technologies involved and cost of this type of device.

2. Non-Impact Printers

Thermal Printers

These printers use a special silicon chip in which a miniaturized two dimensional array of heat generating spots is controlled from on-chip decoding logic. This chip is brought in contact with a special heat sensitive paper and, while stationary on the paper, the character may be printed by heating a combination of dots.

Considerable improvements have been made very recently for this type of printing technology. First, replacement of the silicon oxide layer on top of the matrix array by a layer of silicon carbide has resulted in improved wear-resistance of the print head. Further, printing speed has been increased from the usual 30 cps to up to 120 cps in the new high speed thermal printer developed by Texas Instruments. This device uses a double print head to print two characters at the same time. The advantages of this type of device are the low cost, quiet operation, compact design, low weight and high reliability.

Disadvantages are the requirement for special heat sensitive paper, limited storage capability of either blank paper or printed output (thermal paper deteriorates with time, unless stored at a low temperature).

This type of printing technology has its application in portable terminals, time-sharing applications and certain types of office machines.

We believe that a certain degree of improvement of this type of device will be seen in the 1980s but it will not gain too much inroad as an output device for stationary output terminals.

Ink Jet Printers

Two basic types of ink jet printers have been developed. The continuous flow ink jet printer produces a stream of electrostatically charged droplets that are directed towards plain paper through deflection plates. Voltages applied to the deflection plates position the dots vertically while the print head moves horizontally across the line to produce the character matrix. In sections where no ink is desired, the drops are deflected into a gutter.

The other type of printer uses the "ink-on-demand" principle. Here, pressurized ink feeds a print head with seven or twelve chambers and nozzles in a vertical row. Each chamber has its own piezoelectric transducer, which propels ink droplets against the paper when activated.

Continuous flow ink printers are capable of very high print quality but achieve only moderate printing speed. A typical example is the IBM 6640 which prints letter quality output at 91 cps or utility quality at 184 cps. Currently, this device costs approximately $25,000.

Ink-on-demand printers are manufactured by Siemens AG, Silonics, A.B. Dick, and Mead Digital Systems. The Mead Digital Systems' unit is capable of printing at 45,000 lines per minute but is used only for specialized utility-quality tasks.

At present, ink jet printers are relatively expensive and have some drawbacks in connection with the handling of ink. However, several companies are conducting continuing research directed towards high-speed, high-quality ink jet technology.

During the 1980s, ink jet technology will be in competition with electrostatic printing and printing technology using Laser scanning. We believe that ink jet technology is likely to have a future in high quality printing on plain

paper for word processing output. It is questionable whether it will be able to compete with impact-type dot-matrix printing, electrostatic printing and Laser printing in micro- and minicomputer output applications, requiring printers in the price range of $1,000 and $10,000.

Printers Using Electrosensitive Paper

These types of printers use metallized paper which is brought into contact with metallic electrodes. The current applied through the electrodes burns away the metal and generates a black spot. Either an array of electrodes is moved across the page or two dimensional matrices of electrodes are pressed against the paper where the character is to be printed. The advantage of these printers is their high speed and low price. Speeds up to several hundred characters per second can be achieved in simple and rugged devices costing only a few hundred dollars. However, the metallized paper is more expensive than plain paper and the output is unsightly and sensitive to fingerprints. However, in addition to applications in the home and the computer market, ruggedized printers of this type are finding acceptance in applications such as computer terminals installed in police cars or in similar environments, where the output is not retained for long periods. Rather than improvements in general performance and technology, we see specialized designs in this technological area during the next ten years to fit OEM high volume applications.

4. Cost Forecasts

The thermal serial printer should be available in 1990 in the price range of $800 to $1,000 for the 120 cps version.

The dot-matrix printer with speeds up to 300 cps capable of printing 132 columns should be in the price range of $1,200 to $1,800 in 1990.

The ink jet serial printer using the ink-on-demand approach will be available in 1990, including tractor feed for continuous form paper, for $1,500 to $2,500 with speeds up to 200 cps.

5. Relevance of Printer Technology for Future Pay Systems

Serial printers of the type discussed here are good candidates for application on future small business computer systems or intelligent terminals based on microcomputer technology. Printing speeds up to 900 cps are presently achievable even with impact printers capable of printing on multiple forms. Speeds of this magnitude are likely to become commonplace at the end of the decade in low cost units. These can be used aboard ship for LES output, check printing and accounting summaries.

H. VISUAL DISPLAY DEVICES

1. Introduction

Visual display devices are extensively used with general purpose data terminal systems, as well as with specialized systems, such as word processors, advanced desk-top calculators, etc.

At present, multi-line or page-sized visual display units are almost exclusively based on the use of a CRT employing raster scanning. One-line displays are very seldom used in connection with data processing installations or terminals of any kind. The most widely used visual display unit in connection with data processing systems is the CRT-based computer terminal. Computer terminals of this type contain a keyboard as the input device. Terminals are equipped with a serial data communications interface allowing either half duplex or full duplex receiver/transmitter operations at various transmission speeds and with various formats and protocols.

CRT computer terminals are most often selected for these applications because of their availability in a wide range of capabilities and display configurations. Also, many kinds of computer terminals are available in a stripped down version with a keyboard and, sometimes, even without a serial interface, requiring a parallel interface similar to those of other peripherals.

Any display unit has to have memory capabilities of some sort in order to refresh and/or sustain the displayed information. General purpose CRT display units usually rely on semiconductor memory. There is also the "self-storing" tube, widely used by Tektronix in their line of graphic display units and graphic computer terminals. Since this principle has never become popular for alphanumeric CRT terminals, we will not consider it for the purpose of this report. However, there are potential future display technologies which have the inherent capability of being self-storing.

In this report, we will confine our survey to purely alphanumeric types of displays and disregard displays with special graphic capabilities.

2. Display Technology

This section covers a discussion of CRT, plasma and liquid crystal visual displays, the major technology contenders over the next decade.

CRT Displays

Most CRT-based display stations or CRT-based computer terminals employ a CRT monitor with a raster scan patterned after the broadcast television standard of 525 lines and 30 complete pictures per second. This standard allows the presentation of 80 alphanumerics per line and up to 23 or 24 lines per page, either using interlaced or non-interlaced raster scan. Most popular for presentation of the individual characters has been either the 5 x 7 dot matrix, which allows upper case and numerics, or the 7 x 9 dot matrix which allows the full ASCII set of alphanumeric characters. The page format as described leaves several raster lines between two lines of the page which are used to display a movable cursor.

Although home television sets have been used for this purpose and are still popular in connection with hobby microcomputers, their overall quality, stability, and display resolution are not sufficient for most data applications. A typical CRT-display unit designed for computer terminals and CRT consoles has a special high resolution tube in addition to deflection units (yoke coils) of sufficient linearity. The screen size for this type of display for operator-based work stations is usually between the diagonal sizes of 8 and 14 inches.

CRT-display units of even higher resolution have appeared in systems such as word processors which are required to display one typewritten page at a time. Here, nonstandard rasters with up to 1,000 lines and more, in connection with even higher quality display tubes, are being used. At present, however, such high quality display systems are relatively expensive and there is no indication that they will be used extensively in data processing applications in the near future.

Color Display Technology

Color display units are being offered from a few manufacturers. These units employ a high quality color tube similar to that used in color television applications. Color information stored within the refresh memory is decoded and controls a choice of between three and up to ten different colors and shades for the displayed characters, information field, and the background of the page.

Color video displays have not become too popular for alphanumeric display applications. The disadvantages are the relatively high cost, the reduced sharpness and resolution of the image, due to the properties of the color tube, as well as the susceptibility to mechanical damage by vibration. Most customers and system designers do not believe that the benefits of colored alphanumeric displays in the data processing environment justify the added cost and other disadvantages. However, color displays have reached some degree of popularity for high-priced graphic display systems. Also, some observers feel that the color display capability would be very desirable for advanced word processor systems. Further, several newly developed home and hobby computers employ small color television sets as display units. This development might well lead to general familiarity with color features on alphanumeric displays and ultimately to a user demand for commercial display units with color capabilities.

At present, the single unit component price for a 12-inch CRT unit with the video interface for up to 20 to 25 MHz is approximately $110 to $130 in single quantities and around $70 to $80 in low- to medium-volume OEM quantities. The technology employed in such units is quite mature and we do not expect significant reductions in cost over the next decade.

Flat-Screen CRT Displays

These displays have been specially developed for application in certain military weapon systems. However, the cost of these specialized units is considered to be much too high for application in data processing equipment. There is, however, currently a development program in progress in the United

Kingdom under contract for the Sinclair Corporation, a manufacturer of pocket television sets and other exotic appliances. This is a 3-inch diameter flat screen television tube which has the potential of being very low cost. Whether or not this development will be successful and utilized in data processing display stations is not yet evident. In our opinion, there are few advantages in a flat screen CRT unit to justify a premium price for such a device.

Plasma Display Units

Plasma display panels are flat units capable of initiating or extinguishing a plasma discharge at any of a large number of discrete points throughout the surface of the panel. Thus, any configuration of illuminated points can be arranged on the panel. The plasma display is inherently self-storing and does not require external refresh memory. Alphanumeric plasma displays with a small number of characters are being manufactured in volume. Page displays have been constructed by various research groups and have even been manufactured in small quantities, particularly for high precision graphic displays. However, the addressing of the individual points and interconnection of the large number of electrodes within the display addressing logic is quite involved and expensive. We have not found any evidence that these problems are likely to be solved soon. We believe that plasma display panels will be used only for very special applications which justify the relatively high cost which has to be paid for these units, at least through the next five years.

Liquid Crystal Displays

Liquid crystal displays are currently used extensively in watches, clocks, pocket calculators and similar devices. We expect that single line alphanumeric displays will become generally available at very reasonable costs within the next 24 months. Multi-character or one-line LCD displays require extensive decoding and multiplexing circuitry, based on specialized integrated circuits. This circuitry and the interconnection with the display becomes increasingly more complex as the size of the display increases. Multi-line or page-size displays, which are not yet available, not only present more difficult design

problems for the display, but will only become economical whenever the interconnection problem with the decoding and drive electronics can be solved and mass production can take place. We see some indication in this direction and expect that displays of this type will become available around the mid- or late-1980s in sufficient quality and at prices enabling them to compete with CRT displays at that time.

Within the immediate future, multi-character and one-line LCD displays will be available for applications not requiring a full page capability. This will include portable and hand-held terminals, word processor input stations and in all likelihood, data input and display stations with limited or specialized capabilities. One advantage is certainly the very low power consumption of an LCD display when compared with the consumption of a standard CRT unit.

Currently, a serious disadvantage of LCD displays is their limited lifetime. While watch displays just a few years ago did not last for much more than a year, a lifetime of a few years has been reliably achieved. However, certain types of LCD displays are reported to be adversely affected in humid environments. It has yet to be seen whether long lifetime displays with proper encapsulation will be able to take care of this problem in the future.

3. Technology Trends of CRT Display Units

CRT-based terminals are usually classified as either dumb or intelligent terminals. These basic abilities require a refresh memory, capable of storing 1,920 characters for a display of 24 lines with 80 characters each. Usually, 7 or 8 bits are required per character. Further, elaborate clock and timing circuitry is required in addition to a character generator which contains a ROM and other circuitry necessary to generate the matrix-based character display. Additional elaborate logic is necessary to enter characters at the end of the current line without interfering with the read-out of characters for the purpose of refreshing the display.

In the past, MOS shift registers were used as refresh memory and small scale integrated logic plus discrete components for the clock and timing, character generator and other necessary circuits. As of this writing, it is customary to use static or dynamic RAM of relatively large scale integration for the memory. Special chip sets for the timing circuitry have become available. Control of the other logic functions, particularly the input of new information into the memory plus line and page erasing, etc., is either done with special controller chips or with specially adapted standard microprocessors. These relatively recent developments have resulted in cost reductions of memory and auxiliary circuitry for so-called dumb terminals and display units. A further result is that additional features, previously not found in bottom-of-the-line dumb terminals can now be implemented with almost no additional cost with firmware in the microprocessor. Such features include full cursor control from the computer, control of special display features, as for example, linking of characters or fields, contrast inversion for characters or fields (black on white background), etc.

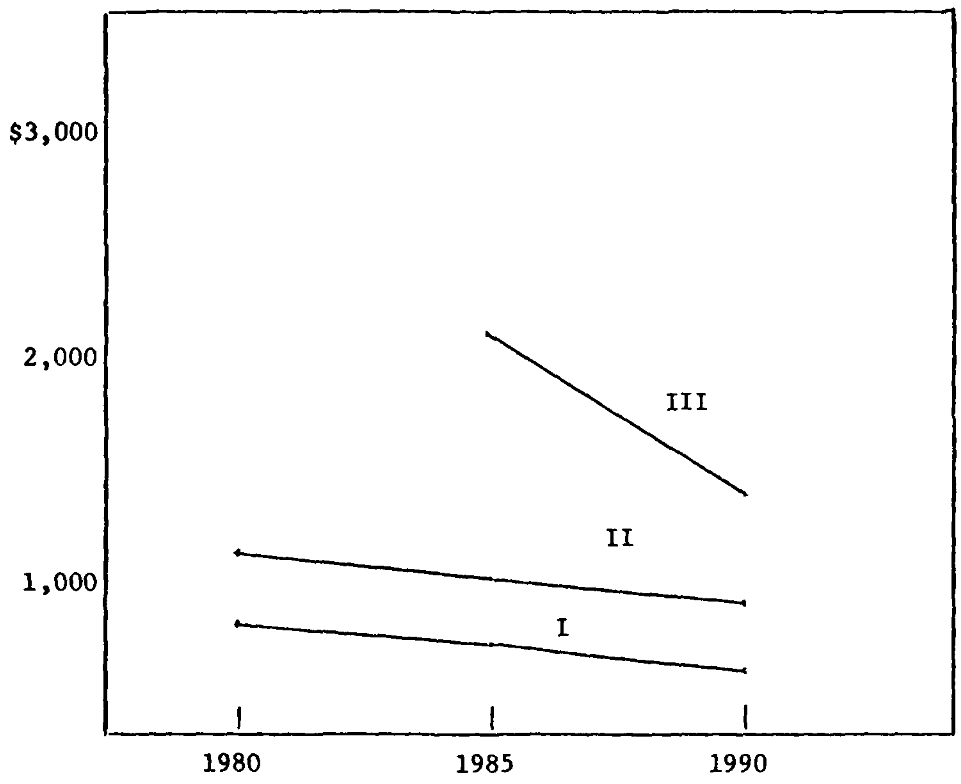
For applications with a display unit as the terminal and a keyboard, the original dumb terminal keyboard transmitted each typed character to the computer which either returned the character to be displayed or took other action, depending on the software. The more elaborate class of CRT terminals could be used in a buffered mode. Here, the operator writes into display memory in any format without immediate transmission to the computer. Depending on how elaborate the local logic is, the terminal may allow editing and other operations. Finally, the page or transaction may be transmitted in one block to the computer. Also, printer interfaces allow the printout of the locally typed page or a page received from the computer. Such terminals or display stations have been available for a long time, but at a higher price than dumb terminals, although they are not usually programmable at all. We believe that the recent introduction of microprocessor-based CRT terminal controllers makes these features available at almost no additional cost when compared to the basic dumb device. Unfortunately, today's terminal prices do not yet reflect this impact on the state-of-the-art.

4. Cost Trends of Display Units

Exhibit VIII-3 provides our forecast for two types of CRT display units. The capacity of each type is 24 lines of 80 characters each, with a 12-inch diagonal screen. The lower cost unit assumes no keyboard, serial receive interface and a few basic features such as remote cursor control. The second CRT unit has, in addition to the basic features, a full alphanumeric keyboard with additional numeric keypad, local editing capability, printer interface and advanced display features such as blanking, contrast inversion, etc. It also features a user-protected information field and field-related input capabilities.

A third line shows our forecast of what we believe might be the future cost trend of the upcoming LCD one page display technology. Here, similar features and display capabilities of the more expensive CRT unit are assumed.

COST TRENDS OF DISPLAY UNITS



I. 12-inch, CRT display only.

II. 12-inch CRT with keyboard, editing capability, other options

III. Cost of terminal as in II, but with LCD page display instead of CRT.

EXHIBIT VIII-3

I. OCR EQUIPMENT

OCR equipment has reached a high degree of maturity. Throughout the decade of the 1980s, the same basic types of OCR equipment currently on the market will prevail. Most improvements will have the effect of increasing the capabilities, the versatility or adaptability to different modes of operation and not change the basic configuration of the equipment. One of the most significant changes will be in accepting compressed digital facsimile page images for OCR functions, rather than only paper documents.

The basic types of equipment to consider are as follows:

- Large OCR readers. These machines are capable of handling a wide range of paper formats as well as different paper weights and can read between 30 and 50 pages per minute. These machines may be equipped to either read only one specialized set of characters (for example, OCR A or OCR B) or may be of the multi-font type, capable of reading a variety of characters, including standard typewritten information. Prices range from approximately $200,000 for the simpler variety of this machine to more than $300,000 for the multi-font type.
- OCR readers for word processing applications. These devices have become popular during the last few years. They can handle typically up to five or ten typewritten pages per minute, are limited to one special font and require good quality typewritten pages of set dimensions. They sell typically for between $16,000 and $25,000 each.
- Hand held readers. Such wand-type readers are manually guided along a field written in special OCR characters. A large fraction of these type readers used in North America are manufactured by Recognition Equipment in Dallas, Texas. They sell currently for between $1,000

and $1,500 for the "wand." A complete OCR terminal containing a microprocessor, a CRT screen and a printer in addition to the wand is currently priced at approximately $6,000 to $10,000.

- Facsimile processing equipment. This is a technology still in the research state, which we believe to have considerable potential. Electronic circuitry is used to process the electrical signal from a facsimile machine. In this process, alphanumeric characters contained in the original document are recognized and converted into digitally encoded (ASCII) form.

2. Future Trends for Large OCR Readers

This type is the only one suitable for applications in large data processing centers. The cost of these machines, as far as the basic reader and document handler is concerned, is largely in the mechanical complexity of the machine. It is therefore unlikely that such machines will become less expensive during the decade of the 1980s. Also, it is unlikely that these machines will be manufactured in significantly higher volume than they are today. However, slight improvements in the technology employed in the reading mechanisms and associated electronics might reduce the cost for this part of the machine. It appears possible that the lower cost machines ($200,000 to $250,000) will offer additional features in 1990, possibly improving multi-font capabilities or at least adaptability to different fonts for basic configurations for approximately the same price.

3. Word Processing OCR Readers

This relatively new class of equipment depends for its survival and further evolution largely on the sucess of its intended application in word processing systems. There is, however, some doubt about the practicality of this set-up in the office-of-the-future at the end of the decade. As soon as inexpensive input stations with either communications capability or removable medium become available, it is likly that word processing users will turn to these instead of

using the more cumbersome OCR process. Also, this class of device is susceptible to smudged documents and other imperfections and requires a very high quality typed page for proper operation.

4. Hand Held OCR Readers of the Wand Type

These readers, which are currently limited to reading strictly one type of OCR characters, certainly have the potential to be developed into a more universal tool, capable of reading multiple fonts. However, applications in the past have been limited largely to those where relatively simple documents, for example, price labels, credit cards and similar ones had to be read. Unless new and high-volume applications are found, there is likely no incentive to develop the specialized chips required to make this type of device more flexible.

It is quite possible, however, that this type of device will slowly gain acceptance in additional field applications with the result of moderate cost decreases by 1990.

5. New Technologies

There is currently a certain amount of R&D work being conducted, especially among Japanese companies, to develop electronic means for the recognition of alphanumeric characters on documents which have been scanned by a remote facsimile machine. Different principles have been evaluated for either converting the images of machine-printed or hand-printed characters on a page into digitally encoded character information.

Such technology has the potential of becomming relatively low cost. Facsimile machines, and particularly facsimile input devices, are already available at relatively low cost. The image processing circuitry necessary for the chararacter recognition process is purely electronic and will have to utilize present or future low-cost microprocessor techniques.

It is evident that such a device could constitute something like a "missing link" for the office-of-the-future. There will be many applications where the

possibility to extract alphanumeric information from a given document for input into a computer or word processor would be highly desirable. Such a device would be used to extract alphanumeric information out of the electrical facsimile signal received from a distant location through a telecommunications channel.

We believe, however, that it is not certain whether enough applications for such technology would be found to make it worthwhile to develop this technology into a practical product and to make such products available at reasonable price levels. It represents, however, a software development of low risk which could be done for a few million dollars.

5. Cost Trends of OCR Equipment

Large OCR Readers

Machines capable of reading between 30 and 40 pages per minute will cost \$200,000 to \$250,000 in 1990. They will likely be capable of reading several types of fonts.

Hand Held Readers

In 1990, we expect that "wand" OCR readers will sell for between \$800 and \$1,000. This will be a unit capable of interfacing with a minicomputer or an intelligent terminal at a standard I/O port.

Facsimile Recognition Processing Equipment

This type of equipment is likely to appear on the market in the middle or later 1980s. By 1985, we expect that equipment of this type capable of processing three to eight page images per minute will cost in the range of \$3,000 to \$5,000. Provided it is well received in the scene of the office-of-the-future, we expect that by 1990, there will a low-speed and high-speed version of this kind of equipment:

- Equipment capable of handling three to five page images per minute will be priced at $1,500 to $2,500.
- Equipment capable of handling ten to twenty page images will be priced at $2,500 to $4,000.
- Equipment able to handle thirty to forty page images per minute will cost $7,000 to $10,000.

These prices are only for the processor portion of the recognition equipment and assume separate file storage facilities for the resultant data.

6. Application of OCR for Future Navy Pay Systems

OCR is a proven means of generating computer input from ordinary documents typed on the OCR type font-equipped typewriter. Documents, including personnel records, which are created aboard ship may be transmitted to the data processing center through facsimile. Here, even the standard data processing type of large OCR readers could be modified to convert these document images into computer input without having to scan paper documents or even creating a paper document at the receiving end.

If, by 1990 or during the beginning of the 1990s, electronic equipment for the extraction of alphanumeric information from electrical (digital) facsimile signals becomes not only technically feasible but available on the market, this equipment might be used to directly convert the received signal into binary character information. Facsimile output may still be employed to create hard copies of the selected documents for permanent storage, if desired. Otherwise, storage in compressed digital form on digital videodisk could prove attractive.

The wand hand-held OCR reader might find interesting applications for ship stores in connection with point-of-sale terminals to read information on credit cards, labels and tabs attached to merchandise and to read individual lines or fields of information typed on documents for administrative purposes--such as a member's serial number from a previous LES.

The word processing type of OCR reader is unlikely to fit either of these two applications. It would be too slow for a large scale data processing installation and too expensive for anticipated use aboard ship.

J. CASH DISPENSING EQUIPMENT

Cash dispensing terminals are currently offered by NCR, IBM and others. These terminals are successfully used by many banks around the world. We believe that they will have interest for future pay systems for shipboard application to eliminate check cashing lines and increase service to the Navy members.

In the following, we will briefly describe the equipment currently offered by NCR, as typical offerings. We see little major changes in the configuration or pricing of these units over the next decade, because of their basic electromechanical nature.

1. NCR Automatic Teller Machines

NCR offers two machines, the 1780 ATM which operates through a wall, and the 1770 ATM which is a free standing unit, intended for applications within the lobby of a bank.

Both units rely on plastic credit cards similar to those used by American Express, Visa and others. Essentially both machines are identical; the main difference is that the through the wall unit is enclosed in heavy steel, safe against break-in attempts while the stand alone unit is not heavily shielded because the operating environment is constantly guarded by employees.

Both machines perform the functions of dispensing cash and receiving deposits. For shipboard use, the depositing function could be eliminated. Cost savings would result from this elimination only if sufficient quantities of such machines would be ordered with this modification--an unlikely situation.

Both machines use a combination of a numeric keyboard with a number of special function keys with a CRT visual display unit. Functions assigned to the special keys may be displayed on the screen, thus making implementation of special functions very flexible. Both machines can be set up to dispense any combination of two denominations of bills (of a wide-range of sizes). Both machines use special cassettes which hold 2,000 new bills of each denomination

of currency or roughly 1,300 used bills. The cassettes can be adjusted for different sizes of currency, which is of interest for application aboard ship if the ship is at foreign ports.

For the stand alone, unshielded cash dispenser, it is an accepted mode of operation to remove the cash cassette after office hours and store it in a separate safe. NCR is currently developing a "tamper proof" cassette, in which employees cannot remove money bills unless they have a special key.

Both cash dispensing terminals use a very elaborate mechanism to ensure that money bills are actually dispensed and that no bills are sticking together. Bills which do not pass the final precautionary tests before reaching the hands of the customer are returned to a special tray as are bills which are not accepted by the customer. The value of bills returned to this tray is automatically credited to the customer's account.

Both the 1770 and the 1780 machines require a special controller which is based on the 3250 computer. Each controller can control several cash dispensing terminals located within the same general area.

For use on-board ship, it might be of interest to use the 1780 free-standing unit and place it into a generally guarded area rather than using the 1770. The latter, due to its heavy steel shield, weights 2,500 to 2,700 pounds, which might be excessive for ship use.

Both machines require an AC power supply of relatively close tolerances as far as voltage and frequency are concerned. Power outages during operation do not cause loss of money bills but return partially dispensed bills to the receiving tray inside of the machine.

Pricing

The prices for the U.S. Government of these devices are as follows:

1770 ATM (No safe)	$13,000
1780 (With safe)	24,350
1780 with controller and safe	27,000

Little price change is anticipated over the next decade.

Technology Trends

From detailed discussions with NCR engineering personnel we concluded that it is unlikely that new technologies will result in cost savings of such automatic teller machines. The cost of the terminal portion of these machines is based on the quite complex electromechanical setup necessary to handle, check and dispense individual bills. Although slight cost reductions might be possible within the next ten years, provided that the manufacturing volume increases considerably, not much change in technology is expected in general. The cost of the controller function will be lowered greatly, due to use of advanced microprocessor technology, but the cost of electromechanical parts of the system will increase due to general inflation to offset these reductions.

K. POINT OF SALE TERMINALS

Point of sale terminals allow an operator to perform and summarize individual sales transactions, involving the collection of cash or other types of payments, typically using credit cards. A hard copy receipt with details of the transaction printed on it is issued.

Devices of this type are built around a central processor, typically a microprocessor. The keyboard, consisting of numeric keypad, sometimes even a full alphanumeric keyboard augmented with special function keys, is included. Visual display units, either a general purpose small CRT, or in other cases, specially laid out displays composed of individual fields capable of displaying fixed alphanumeric information through back-lit panels are included.

Such basic configurations are augmented with a number of peripherals, including receipt printers of various types, credit card readers, wand readers for bar tags attached to merchandise, as well as telecommunications interfaces for the data lines connecting these terminals with the main computer. Further, terminals of this type used for transactions involving the exchange of cash often include a cash drawer, the function of which is controlled by the internal processor.

An essential part of these point of sale terminals is the special operating software which has to be tailored to the particular application. Under control of this software, the operator is guided through a fixed sequence of entering data, pushing specific buttons during this sequence which indicate types of transactions, types of merchandise exchanged, or other details. Further, credit cards have to be inserted into the appropriate reader or card numbers entered manually during the course of the transaction.

In 1990, there will be a great variety of configurations of such terminals, composed of standardized modules which can be put together to serve the need of an individual application. Only those peripherals needed will be included in a package. Further application software will be largely "prefabricated" in order

to serve a large variety of standard and special purpose applications. This prefabrication consists of storing a large number of universally applicable software modules as well as special modules for distinct applications on a computer disk file. A software system generates a program then accepts coded input relating to the intended application of the device and translates it into a selection menu for the software modules and submodules required. Finally, those modules are called from disk and assembled and linked into a complete application package which then is stored on a transportable medium for transfer to the customer installation.

We believe that in 1990, typical point of sale terminal devices, depending on the complexity and type and number of peripherals, will cost between $2,000 and $4,500 with the majority of devices in the range of $2,500 to $3,500.

1. Intelligent Credit Card

While advanced point of sale terminals in 1990 will largely consist of central processing units, display units and peripherals of the general types already available today, there is one area in particular where it appears that the application of advanced technologies could result in a completely new scope of operational features. This is in the credit card, or its "intelligent" successor.

Credit cards are likely to increase their already important role in business and financial transactions in the future. Their use aboard ship is likely to simplify many such transactions. Typically, we expect that credit cards could be used for many of the purchases in shipboard stores in connection with automatic teller machines and several other applications. At present, credit card technology has several limitations. First, the amount of information that can be magnetically encoded on these cards is very limited. Second, it is not considered practical to record actual account balances on these cards. The recording medium and procedures cannot easily be made tamper proof for such applications.

Concepts of so-called "intelligent" credit cards, containing advanced microcomputer circuitry, have already been proposed in several countries of the world. We believe that the following concepts could be implemented in a cost efficient and reliable way around 1985 or 1986.

A small device of the general outlines of the credit card, or possibly having the thickness of the modern flat pocket calculator, would contain the following semiconductor circuitry:

- A small microprocessor to control access through various access-denial techniques
- EAROM to provide nonvolatile storage of data
- Small amounts of RAM to carry balances
- ROM for storage of firmware
- Input/output buffers, including the necessary interface circuitry
- Electrical contacts at the edge or on the surface of the card for the necessary connection to the card reader for application of operating power as well as transfer of information into and from the circuitry contained in the credit card.

For the purpose of prohibiting unauthorized alterations of the information content stored in the card, a data security algorithm has to be implemented in firmware in the microprocessor. Data to be recorded in the memory contained on the card by the card reader/recorder will either be encrypted or otherwise complemented with additional redundant information in order to satisfy the needs of the security algorithm. Only data recognized as valid will be stored in the on-card memory. There does not seem to be any immediate reason why retrieval of information from the card should be subject to any special authorization, but a similar procedure could be implemented for this operation, if so desired.

EAROM, some forms of which are already becoming available, would allow storage of recorded information indefinitely for retrieval and would allow alteration or override of this information at any time.

Pay Systems Considerations

Whether an entry on such a portable "intelligent" credit card should constitute the only system-wide record of the balance of the personal account of the bearer is a question of practicality. Implementing the system in this way would certainly ensure that the bearer could withdraw cash not only on the ship where he is normally based but also in different locations equipped with appropriate facilities. Also, members transferred from one ship to another would automatically carry their pay record, or at least the most essential portions of it, to the new location, minimizing the amount of administrative work. However, in order to guard the system against the effects of loss of such credit cards or of improper use, it appears necessary to keep a copy of the account balance in a file within the local computer installation serving the unit to which the member is currently assigned. A unified sign-off procedure could be implemented which terminates the account at this location in case the member is transferred and makes an entry to that effect on the "intelligent" credit card. As soon as the member signs onto the system in the new location, this mark would be removed and the status of the account balance would be transferred to the backup file in the system serving the new location.

L. FACSIMILE DEVICES

The trend toward digital compression of facsimile information prior to transmission has given new life to an old system concept. The next few years will see increasing standardization from which some degree of compatibility between devices from different manufacturers will result--the lack of which has hindered "public" use of facsimile for electronic mail.

The current activity of the CCITT to standardize four different classes of machines will be completed in a few years. During the 1980s, facsimile devices will be characterized by the four CCITT groups:

- Group I includes all additional machines based on FSK (FM) transmission at low data speeds and requiring five to six minutes per page.
- Group II is the improved version which is currently becoming most popular. It is based on AM modulation methods for transmission, uses some degree of data compression (analog mode) and requires three minutes for transmission of a page.
- Group III is the most modern type, based on digital data compression methods. It transmits a page in less than a minute, typically 30 seconds.
- Group IV will be the standard for even faster machines; CCITT standards are not defined.

Currently, only machines of Group I, which constitute approximately 80% of the installed base of 300,000 facsimile devices throughout the United States, use a generally accepted protocol. These machines, however, are often not compatible with similar machines from different manufactuers.

There is a strong tendency within CCITT and other standard-setting associations to achieve a higher degree of standardization in order to make machines of different manufacturers more compatible with each other and with upcoming

public network standards. It is likely that these activities will have to continue for several years. We believe that around 1990, there will be a reasonable approach to standardization, at least among the first three groups of machines.

Practically all current machines are based either on a resolution of 100 x 100 lines per inch or 200 x 200 per inch. While the lower resolution is acceptable for the reproduction of typewritten pages, the higher resolution is necessary if typeset material or more sensitive graphical displays have to be sent. It is likely that these two resolutions will still prevail around 1990 for most office applications.

Scanning Technology

In general, the following document feeding configurations will be available in the early 1990s:

- Automatic document feeding devices. These devices permit the insertion of one or more documents to be scanned and transmitted automatically at a later time when communications channels are available. These devices will include elaborate mechanisms for document handling, similar to those used in automatic feed copying machines.
- Scanners with manual document feeding. Such devices rely on manual insertion of individual documents and will generally be much less expensive than automatic document feeding devices. They will be used where immediate transmission is needed, or where store-and forward capabilities of the network allow immediate scanning in combination with later transmission without cost penalty. Scanning of pages from books or brochures will be necessary for certain operating environments and will be possible only with this type of device.

Laser scanning, photodiode scanning, and CRT-flying-spot scanning techniques are employed. Of these, only the Laser scanner and photodiode scanners will remain through the coming decade. Both will be employed for one line and multiple line scanning. However, it is likely that self-scanning large arrays of photodiodes will be used to scan full lines at a time, possibly even multiple lines at a time.

Self-Scanning Photodiode Arrays

Linear as well as two dimensional self-scanning photodiode arrays are currently under development. Such devices have already been used to replace the imaging tubes in black and white and color TV cameras. An array of between 800 and 1,500 photodiodes can be used to scan a line at a time and eliminate the fast moving line scanning mirror arrangements. Combined with constant velocity document feed (or a relatively slow moving mirror), this will result in a mechanically simple and rugged document scanner.

In 1990, a variety of mechanical arrangements for document scanning will be available, either for manual or automatic document feeding. Because of the trend towards intermediate storage of facsimile scanned information, scanning speeds will depend largely on required throughput of the application for the scanning station. Various electro-optical scanning methods will be used, based either on Laser scanning or photodiode scanning with either single or multiple photodiode arrays.

Facsimile Output Devices

Presently, facsimile output devices print on paper with either electrolytic, electrothermal, eletrostatic, dielectric or photographic processes. It is very likely that most of these processes will still be in use by 1990; however, we envision a trend similar to the one which took place with office copiers during the next ten yers. This trend would favor high quality processes, capable of yielding clear, clean and high-contrast copies on plain paper for general office applications. Also, it is very likely that traditional photographic processes will disappear first, as they did with office copiers, due to the high cost as well as the complexity of the process.

A new type of facsimile output device was recently introduced by Siemens. This device uses an ink jet mechanism to print the several subsequent lines of the document simultaneously on plain paper. Such devices, together with various types of electrostatic processes, are likely to gain in favor over the next ten years.

Currently, most facsimile machines print the output at the same speed they receive information over the communications channel. In 1990, there will be a variety of output technologies and mechanisms with printing speeds determined by the number of documents which have to be generated per hour, while transmission speeds over a communications channel will be independently determined by the volume to be transmitted, the cost per unit of time on the channel, type of digital compression utilized, and other relevant factors, using store-and-forward techniques on the digitized page image.

Further, there will be a variety of mechanical designs for output devices, depending on whether output has to be printed on individual sheets, rolled paper or other forms of paper. Most sophisticated designs will include means for the accommodation of formats smaller than the maximum page size. This will include automatic trimming of the excess paper from a received document.

Data Compression and Transmission Control

The popular Group I equipment uses no data compression at all. It is generally realized that this type of equipment, even if used infrequently, results in a high cost of ownership, due to the high cost of the transmission time employed. Group II equipment, which is currently becoming more popular, uses a modest amount of analog data compression. Group III equipment, which is likely to become the favorite type of facsimile during the later part of the 1980s, uses a digital, "run-length" encoding scheme which is very effective in reducing the amount of data to be transmitted. Machines of this type include a modem capable of transmitting betweeen 2,400 and 9,600 bps. They are generally capable of transmitting the page in less than a minute.

By 1990, more capable specialized encoding schemes will be used and largely standardized. Companies such as Compression Labs, Inc. have already introduced independent electronic devices to perform the digital compression and data expansion. These devices are intended for use with Group I or II facsimile machines. They accept the input from facsimile machines, store it in memory and perform the data compression function. At any time, the compressed data may be transmitted over the transmission channel to the far end, where a second device of this type receives the information, expands it, stores it in memory and, on request, sends it to the attached facsimile device for output. This particular device may be equipped with an optional floppy disk in order to store many pages of facsimile for later transmission or, at the receiving end, for later output. A device of this kind costs currently around $42,000. We believe that this is a trend-setting development, which has the potential of becoming considerably less expensive due to the progress already made and expected in the near future in the area of microprocessor technology and memory cost production.

We would think that a 3:1 to 5:1 cost reduction of the functional equivalent of this device is likely to occur during the 1980s, leading to store-and-forward digitally compressed facsimile modules (excluding scanner and printer) of around $10,000.

Facsimile Machine Configurations

Currently, facsimile transceivers consist of document scanners, output devices and data transmission and data compression circuitry. Scanning as well as output speed is usually matched to the time the machine requires to transmit the image to the communications channel. In 1990, there will be the same type of machine available as a stand alone unit, but capable of higher performance at lower cost than today. However, we think that the development is largely towards a modular approach. Output control as well as data compression will be combined with appropriate modems or interfaces to digital transmission channels and microprocessor control of the transmission channel. Further, modules for off-line storage, store-and-forward operations and for other purposes will be available for use in facsimile machines and facsimile networks.

Thus, in addition to stand alone facsimile machines which will be built from such modules, there will be a variety of stand alone facsimile document scanners and output devices which are connected with either individual or shared compression and expansion modules and through a modern digital PABX, connected with a communications network. Facsimile store-and-forward capabilities may be either a part of the terminals, of the PABX or of the network.

Sharing of Peripherals

Laser page printers for computer output are usually capable of accepting the visual-type input signal. Equipped with the appropriate interfaces, such printers are perfectly capable of reproducing a facsimile image on paper at a relatively high speed. In 1990, there will be a variety of such interfaces available, allowing use of the upcoming generation of Laser page printers for a variety of applications, which will include computer or terminal output, word processing output, typeset, as well as facsimile output. Some of these devices may also be used for everyday copying applications.

Converters are already offered on the market which make it possible to use a facsimile machine as an output printer for alphanumeric information by accepting alphanumeric output from a minicomputer or terminal and converting it into an appropriate facsimile signal. It is most likely the the current distinction between text printers and facsimile output devices will disappear to a certain degree within the next ten years.

Facsimile Output on Visual Display Units

Many facsimile applications do not require hard copy output at all. It is quite possible to display a received facsimile message on a CRT screen or other advanced visual display device. If a store-and-forward system is used, such viewing could be very attractive, since several recipients of a message can read it on a screen and comment on it without having to generate an output on paper. While this mode of operation is currently technically feasible, it is not often employed. We know that certain manufacturers are preparing to offer systems of this type in the very near future and are quite enthusiastic about the viability of this concept.

Cost Trends of Facsimile Devices

The least expensive Group I or Group II stand alone facsimile machines cost today between $1,000 and $2,000. Such machines, which require manual operation and insertion of individual documents, are likely to become slightly less expensive by 1990. However, machines with automatic document feed, auto dial or equivalent capabilities, which are capable of unattended operation and would currently cost between several thousand and well above $10,000, will become available at a lower price as manufacturing volume builds up. It should be taken into account, however, that the high cost of such machines is largely due to the mechanical complexity of the document and paper handling mechanisms and not so much due to the basic scanning and output device in electronic circuitry. Therefore, the potential for cost reduction should not be overestimated. A price in the $3,000 to $5,000 range in 1990 is considered reasonable.

The most significant cost reduction will be experienced with electronic circuitry responsible for data compression and handling of the transmission function. Here, we may expect that machines with the sub-minute transmission speed characteristic of Group III will become available at prices currently charged for Group I or Group II machines. Further, very inexpensive simple document scanners may be available for widespread distribution through the office environment, capable of accepting manually inserted documents for copying or transmission and hooked up with modern digital PABX systems for transmission of the image information into a store-and-forward transmission network. This may be a separate network or part of a generalized data communications network. Data compression and expansion may be performed either in the terminals or in the network. Scanning devices of this type are likely to become available at prices of only a few hundred dollars.

Output could be generated either at centralized sites, using high speed automatic output devices, or in combined-output graphic devices capable of printing facsimile and computer output information widely distributed through the office, or, if necessary, on individual slower output machines used by only one or a few individuals. Slow output devices of this type are likely to become available also at a price of only a few hundred dollars each.

Relevance of Facsimile Technology to the Future Pay System of the Navy

Facsimile is developing into a readily accepted communications medium for the office-of-the-future. A facsimile communications channel between ship and shore could easily be used to transmit documents in both directions. This would allow the transmission of plain paper documents without retyping on terminal devices. Even hand written corrections and other remarks could be transmitted with the document. While documents received on the ship would be of relatively low volume and data contained in these documents could, when necessary, be entered manually into the shipboard computer installation, documents received at NAVFINCEN would have to be entered into the data processing installation in a different way. New Image Character Recognition (ICR) readers could be used on the facsimile output, provided that this output is of high enough quality. Ultimately, direct conversion of selected fields within the facsimile image into alphanumeric information could become available in time for systems to be implemented in the late 1980s or early 1990s. This might prove to be an excellent medium for data entry in this environment, since it permits direct entry of the data into the computer and to create an optional hard copy output for later reference if so desired.

IX

TELECOMMUNICATIONS SUPPORT TECHNOLOGY TRENDS

This chapter outlines those developments in telecommunications which can impact the system concepts developed Navy shipboard military pay systems.

A. MAJOR TECHNOLOGICAL DEVELOPMENTS CONTRIBUTING TO NEW TELECOMMUNICATIONS PRODUCTS/SERVICES

There are only a few major new technologies which will have a significant impact on telecommunications capabilities and costs during the coming decade. These technologies are:

- VLSI circuits
- Digital switching and transmission techniques
- Optical fiber transmission
- Advanced satellite technology in the 10 to 20 GHz range
- Development and standardization of PASCAL and derivative languages for telecommunications-oriented software

1. VLSI Circuits

As discussed earlier, a number of developments are supporting VLSI technology improvements. Using the short wavelengths available with electron beam or X-ray lithography, the linear dimensions of an active element can be reduced by an order of magnitude, and the area occupied by the active device by at least two orders of magnitude, over the next decade. Developments are already underway for line widths of 1 micron. It is anticipated that the practical limit for a single chip in CMOS circuitry will be operation at 400 to 800 millivolts, line width of 0.25 microns, and 1 watt dissipation at an operating frequency of 100 megaHertz.

The amount of memory on a single chip has been doubling every two to three years and is now up to 64 kilobits in production quantities. This trend will continue with chips containing as much as one million bits (100,000 bytes) of memory by the early 1990s.

The small size, high reliability and low power consumption of these components will make them particularly suitable for satellite processing. Two major improvements are the ability to perform on-chip testing and the ability to bypass or eliminate bad individual components on the chip without making the chip unusable. This bypass capability maintains a high chip yield in the manufacturing process. This approach is also likely to be utilized in self-repair approaches implemented in the early 1990s for satellite electronics.

The low power consumption forecasts for both microprocessor and memory chips make feasible both satellite and shipboard telecommunications facilities using significantly less power than today, while maintaining an improvement in throughput.

These developments in VLSI mean that raw processing power and memory as large as 1 megabyte are basically "free" from a system planning viewpoint. The hardware cost of systems will develop from electromechanical peripheral equipment, visual display equipment, subscriber line interface circuitry, and mass memory which still must be implemented in electromechanical rotating magnetic technologies.

Important for the telecommunications field is the application of LSI and VLSI in the subscriber line interface circuits for both voice and data terminal equipment. Specifically, a substantial amount of circuitry is required to implement protocols--implementing in hardware what previously had been done in software. For this project, we are primarily concerned with data communications, and we will not dwell on the advantages which VLSI brings to the conversion of analog speech to digital speech or to the encoding of voice for lower speed digital transmission.

2. Data Modems

Data modems at 1200 bps and 2400 bps speeds are likely to be implemented in LSI technology within the next decade, since only these will achieve sufficient volume to warrant investment on the part of the several manufacturers. We fully anticipate that the major portion of modems will be done on one to two special

LSI chips, plus a modest amount of discrete circuitry, bringing these to the range of \$500 to \$700 (packaged version) or \$200 to \$400 (printed circuit board) by the mid-1980s.

By the early 1990s, most data communication is likely to be done over intrinsically digital facilities, and analog modems are likely to be so reduced in volume requirements that no further cost reductions can be anticipated.

For 4800 bps modems, insufficient volume will prohibit more than one or two firms going into an LSI version, resulting in the price being maintained for a packaged version with power supply costing in the range of \$2,000 in 1985, and remaining in that price range through 1990.

We anticipate that 9600 bps modems will only be employed on point-to-point analog circuits, and with built-in error control and automatic speed adjustment are likely to be in the range of \$4,000 in the mid-1980s, reducing to roughly \$3,000 by the early 1990s with extended error control, automatic equalization, and other facilities for non-line conditioned circuits.

B. DIGITAL SWITCHING AND TRANSMISSION

A clear trend in the field of telecommunications is towards the rapid implementation of digital switching and transmission facilities within the public dialed network and private network facilities, including the U.S. military network.

Digital Switching Equipment

The introduction of powerful 8- and 16-bit microprocessors is making the cost-effective implementation of digital switching for both voice and data circuits highly attractive. By 1985 nearly all of the advanced countries of the world will be implementing only new digital switching and transmission facilities. During the early 1980s, there will still be some analog coaxial cable implemented for long haul communications, but this is likely to be displaced in the late 1980s by fiber optic transmission systems.

Digital switching equipment for analog voice circuits today is available at a cost-based price to PTT administrations of approximately $230 to $260 per line. For digital switching equipment used for data transmission the cost is in the range of $400 to $500 per data port.

We fully anticipate that by 1985, these prices will decrease to where the analog voice circuit digitally-switched line would be in the range of $200 and that for a data port in the range of $300 per port. Port sharing made feasible by remote or local digital concentrators may reduce the effective cost per data terminal served even further, if the traffic from each terminal is relatively low.

We would not anticipate any further reductions in the cost of voice or data digital switching in the early 1990s, but we believe that advances in technology will be able to assimilate the impact of inflation. The cost of the data port will approach that of the voice port, since the two will essentially become standardized digital data ports, with highly standardized protocols using specialized chips produced in high volume.

C. FIBER OPTICS TRANSMISSION

The use of fiber optics for transmission purposes has several advantages relative to other transmission media:

- In general, higher bandwidth or greater channel capacity
- Lower attenuation with distance
- Freedom from electromagnetic interference
- Increased communications security
- Lower material costs
- Smaller physical size per equivalent voice channel
- Wider repeater spacing

There is already a modest amount of use of fiber optic transmission systems aboard ship to take advantage of some of these characteristics.

The cost per circuit kilometer for short length systems in the range of 3 kilometers, operating at the T-2 rate in 1985 would be approximately $20 for the complete system. In 1990, this is likely to be in the range of $12 per circuit kilometer. For long haul trunks in the range of 500 kilometers, operating at the T-4 level carrying 20,000 circuits, the cost will be around $1 per voice circuit kilometer in 1985, reducing only slightly by 1990.

Interestingly, this is in the same price range as that of satellite systems of 1,000 circuits operating over a length of 2,500 kilometers and digital radio operating at 6 gigaHertz offering 9,000 circuits over the 500 kilometer system length (excluding right-of-way considerations).

The cost of fiber optic transmission systems will be dominated in the mid-1980s by the cost of the electronics to provide the necessary multiplexing, as well as for the repeaters in the longer haul systems. The cost per fiber meter is anticipated to be in the range of $0.10 by 1985 for the simple fiber. The cost of the completed cable is many times that of the simple fiber, and the cost of electronics on short haul systems totally dominates the system costs.

D. ADVANCED SATELLITE TECHNOLOGY

Commercial communications satellites in a geostationary orbit exhibit a number of important characteristics:

- Fixed geographic coverage, covering as much as one-third of the total Earth from a single satellite
- Almost unlimited interconnectability between earth stations within the coverage area
- Elimination of the need for horizon to horizon tracking equipment since the satellite is always in view of the earth stations within its coverage area, and for UHF transmission requires little dynamic pointing
- Specialized forward acting error correction techniques due to the substantial (0.6 second) round-trip delay through geostationary satellites
- Distance insensitive costs within the satellite viewing areas, and almost distance insensitive costs on a global basis by the early 1990s, since intersatellite trunking facilities will be provided
- Provision of wide band services as well as dynamic bandwidth allocation to effectively serve a large number of infrequently used earth stations, such as would be the case for shipboard application

Essentially all commercial communications satellites operate in the 4 to 6 GHz bands. However, by 1990, increasing demand for satellite circuits will outstrip the available capacity of the geostationary orbit for the 4 to 6 GHz range systems, and satellites starting in the early part of the decade of the 1980s will become operational in the 12 to 14 GHz frequency bands. This will permit much smaller antennas to be employed, a multiple spot radiation from the satellite, and continued implementation of Time Division Multiple Access (TDMA) to permit multiple users on a demand basis. By the mid-1980s, most satellites will use in-satellite switching with separate command channels to make the necessary beam assignments and for the coupling of multiple beams. In fact, this form of satellite-switched TDMA will be used with the advanced

WESTAR to be launched in 1981. By the early 1990s, satellites with on-board processors will be capable of performing the switching function based on information contained in the header data of transmitted bursts.

Such on-board satellite switching will make significant use of VLSI technology. An important economic factor in the launching of satellite communications, and in fact in the total cost for satellite communications systems, will be the introduction of the Space Shuttle for most launches. It will facilitate the introduction of physically larger and more powerful satellites with wider bandwidth transponders and more transponders, as well as the added electronics for on-board switching.

We anticipate that even higher frequency bands will be used in the early 1990s, probably in the range of 17 to 19 GHz and possibly even in the 21 to 30 GHz range. We also anticipate that Laser communications, particularly between satellites or between satellites and aircraft, will become an accepted technology in the early 1990s.

Importantly, both domestic service suppliers, and a number of international and regional suppliers of satellite service on a commercial basis will, by 1990, offer low traffic service to ships at sea, as well as to most land-based antenna sites, utilizing either a small UHF antenna or the small 10 to 20 GHz antenna. These small antennas are suitable for shipboard use.

We contacted a large number of organizations involved in the provision of satellite service on a commercial and on a military basis. These organizations included:

- COMSAT General
- Navy Telecommunications Command
- Satellite Business Systems
- Harris Corporation
- Scientific Atlanta
- American Satellite
- INTELSAT
- COMSAT Corporation

1. MARISAT AND INMARSAT

The Maritime Satellite Program (MARISAT) has been in operation for several years, providing teletype and voice-grade circuits on an analog basis via UHF radio to ships at sea. Part of the MARISAT satellite was leased by the U.S. Navy for the Fleet Satellite Communication Program, in lieu of having their own satellite to support the fleet. There are reportedly some four or five hundred Navy ships already equipped with antennas for this purpose. The MARISAT satellite is of relatively modest capacity, and the Navy had leased only a small portion of its total capacity, prior to launching its own satellite.

In addition to serving Navy needs directly on the fleet SATCOM program, the MARISAT also provides voice and data communications capability on a commercial basis. The satellite has the capacity for about 15 full-time VF duplex channels. Only two or three of these were actually in operation as of January 1980. Thus, there is a substantial capacity on this satellite to support other commercial facilities. There are about three hundred commercial ships equipped with UHF antennas and appropriate electronics to support ship-to-shore transmission via the MARISAT system. The MARISAT currently operates in the 4 to 6 GHz band, and in the L-band at 1.5 and 1.5 GHz. It provides UHF transmission facilities.

The MARISAT program will be superceded by INMARSAT, which will be provided by an international consortium currently subscribed to by some 20 countries. INMARSAT will be fully compatible with shore- and ship-based equipment currently used by MARISAT. However, larger capacity will be available--currently planned to be 30 to 50 full-time duplex voice grade channels simultaneously. COMSAT General is currently negotiating for the space segment for INMARSAT. The system will use a portion of the INTELSAT V satellite to provide coverage in some areas and to lease the European space agency's MARECS satellite system to cover other areas of the globe. Implementation of INMARSAT is planned for the beginning of 1982.

INMARSAT will use the same frequencies (around 1.6 GHz) as MARISAT. Therefore, no change in shipboard equipment will be necessary. We understand that

these particular frequency bands are reserved internationally for this purpose. It is considered probable that successor systems to INMARSAT will serve the same frequency band, possibly in addition to other services on much higher frequencies.

INMARSAT will provide capabilities for data transmission in addition to voice grade service. This includes 1,200 as well as 2,400 bps, supported with regular analog modems on a voice-grade connection. Further, a special service will become available in the 1982/1983 time frame which will support transmission of 56K bps from ship-to-shore. Shore-to-ship will be supplemented with a voice-grade channel. We understand that the transmission properties of the voice-grade channels will be such that it might become difficult to support 4,800 bps or more with regular modems.

Presently, approximately 360 ships are equipped with 1.6 GHz terminals for MARISAT/INMARSAT. It is expected that by the end of the planned life for the initial INMARSAT, approximately 2,000 ships will be equipped with such terminals.

The current MARISAT charges $10 per minute for use of voice-grade circuits and $4 per minute for use of a telex channel. These charges apply only when a channel is actually in use. INMARSAT is not expected to be able to reduce these usage charges, unless the number of users builds up very rapidly.

There seems to be some controversy about the properties of satellite systems beyond the initial INMARSAT system. According to the Harris Corporation and American Satellite, it is probable that such systems will operate at higher frequencies, possibly in the Ku band. According to COMSAT, however, successor systems to INMARSAT will remain at the 1.6 GHz frequency.

Terminals for MARISAT/INMARSAT

Terminals for MARISAT/INMARSAT are currently provided by the following firms:

- Scientific Atlanta
- Magnavox
- Japan Radio Company

These terminals typically employ a 4-foot dish-type antenna. While the requirements for the antenna itself are relatively simple, the two access service system plus some sort of initial reference is required for pointing the antenna at the satellite. Terminals not only include transceiver and transmitter, but also a teleprinter and telephone instrument plus a variety of optional interfaces.

Prices for complete terminals, including antenna, range currently from $50,000 to $75,000. We expect that such terminals will experience a modest price decrease throughout the decade of the 1980s.

Terminals supporting the planned 56K bps ship-to-shore transmission mode will be slightly more expensive since a more powerful transmitter is needed in addition to the special digital modulation circuitry. Currently, such terminals are being developed by Scientific Atlanta and Texas Instruments.

Terminals for Future Satellite Systems

Future services, possibly in addition to INMARSAT or services of a competitive nature, may use higher frequencies, such as the Ku band. Here, either a dish-type antenna (mechanically steered) or a steerable phased-array antenna could be used. Such phased arrays could be mounted around a mast in order to provide a clear view upward. Antenna of this type will not only be smaller and lighter but also easier to install on most ships. Harris indicated that they believe that by the late 1980s, an electronically-steerable phased array would be only slightly more expensive than a mechanically-mounted dish antenna, if purchased for programs such as INMARSAT.

2. LESAT

The Navy is beginning to move away from the use of the MARISAT program to provide satellite support to its operational shipboard communication requirements toward the use of its own and leased satellites and satellite transponders. Apparently LESAT already uses three leased satellites. Five satellites

will be launched by the end of 1980, with a sixth being launched by the end of 1981 to support the LESAT program. The MARISAT program, referred to as GAPSAT, will be phased out in favor of the Navy's own satellites.

Within ten years, the Navy plans to launch another technology of satellites using the Ku band EHF, operating in the 20 to 40 GHz range. The architecture of this system will be such that there will be almost unlimited capacity in peace time for data communications capabilities. This will be operational certainly in the early 1990s.

3. Conclusions

It appears clear that there will be both commercial and military satellite facilities in the late 1980s or earlier which could provide reasonably cost-effective two-way communications between ships at sea and land-based facilities. The size of the necessary shipboard terminal is likely to be acceptable for mounting on most ships, and the cost is likely to be less than $25,000. We would anticipate that the cost per minute will be somewhat less than today, probably in the range of $5 per minute for an equivalent voice circuit utilizing these facilities.

We would anticipate at most a ten-hour connect time per month from the largest Navy ship. At $5 per minute, this represents a maximum of $3,000 per month. But the average ship's needs are likely to be in the range of one to two hours of connect time per month, or $300 to $600 per month for the communication channel costs, exclusive of amortization of the satellite terminal. Assuming that some 600 ships were equipped, this could represent a cost of approximately $3.2 million annually. This does not appear unreasonable as a communications cost target to support an advanced system to support military pay administration.

E. DEVELOPMENT AND STANDARDIZATION OF COMPUTER LANGUAGES FOR TELECOMMUNICATIONS-ORIENTED SOFTWARE

In many areas of telecommunications, the cost of software development is already higher than that of hardware development. This is true for advanced stored program-controlled telephone and data switching equipment. It applies particularly to the situation in advanced packet switching data networks.

This trend is likely to continue for three reasons. First, cost of electronic hardware in general is dropping due to advances made in semiconductor technology. Secondly, more and more advanced functions in telecommunications networks and systems are implemented with software-controlled circuitry. This is true for "intelligent" interfaces and protocol handlers, message store-and-forward devices, switching equipment in general, as well as for a wide variety of data compression and encoding devices. Further, telecommunications networks with increasing complexity have to use means for remote diagnosis and maintenance and, in the future, likely for self-repair. All of these advanced features require extensive amounts of software for their implementation.

Presently, much of the telecommunications-oriented software is written either in assembler language or in one of the existing higher level languages usually recommended for this type of application (PASCAL).

Trend Towards Use of Higher Level Programming Languages

While higher level programming languages are customarily used in data processing applications, telecommunications software has, in the past, largely been written in assembler language. However, there is now a strong trend towards use of higher level languages for such applications. This is brought about by rapidly increasing wages for software personnel in conjunction with steadily rising complexity and size of the software systems in question. Concern about higher memory requirements of code generated from higher level languages, when compared with code written in assembler are becoming less pronounced as cost of memory rapidly decreases.

New Generation of Higher Level Languages for the 1980s

While higher level programming languages such as FORTRAN and PL1 and their derivatives have been amended for telecommunications applications, a new class of programming languages is currently emerging. They are derivatives of PASCAL, which itself is an evolutionary adaptation of the well-known ALGOL programming language. PASCAL, like ALGOL, is a block-oriented programming language. It is specifically designed to make it easy to use the modern approaches usually referred to as "structured programming." It allows using a wide variety of data structures, including linked lists, arrays and long strings, which always presented difficulties in many of the older languages. Further, PASCAL easily supports a variety of file structures. Further, it is likely that interpretive compilers for PASCAL will be used, requiring only storage of the source code itself. The effect of this trend will be to make programs written in PASCAL code different computers, and reduce the cost of debugging new software or modifying existing software. The trend towards use of P code compilers, discussed earlier, will continue.

Specialized Versions of PASCAL

While PASCAL itself is considered a language applicable to a wide range of problems, including areas like engineering, data processing, real-time control problems, telecommunications, etc., we expect that several specialized languages will appear which are derived from PASCAL.

This trend is already visible. CHILL is currently being standardized by the CCITT as the worldwide programming language for telecommunications switching applications. Further, the U.S. Department of Defense is specifying a new programming language, also derived from PASCAL, which meets this department's special needs. It has been designated ADA.

Significance of These Trends for Navy Pay Systems

Application of advanced, high-level programming languages in software-supported telecommunications components, like digital switching equipment,

"intelligent" satellite transponders, high performance modems, shipboard satellite terminals and many others, is likely to reduce the cost of writing and verifying the necessary software. This will complement the trend of decreasing hardware costs for these system components which is expected to continue through the decade of the 1980s.

F. VOICE DATA ENTRY

Voice data entry systems have made only slow progress over the past decade, and are likely to see more, but not outstanding, progress in the coming decade, due to the availability of extremely high processing speeds available from microprocessors. This is necessary to achieve the real time processing of voice waveforms.

Recognition of complete phrases or sentences is not anticipated as being commercially feasible within the next decade. However, the recognition of individual numbers, letters, single words selected from a restricted list of words, and short phrases from an abbreviated list of phrases will be commercially feasible within the next decade.

One of the interesting new uses of voice data entry is for the voice input of credit card information for which allows large corporate voice networks to accept and process calls for persons off-net, and from telephones not equipped with touch tone dials (which would allow entry of authorization codes).

In general, for a system to have a relatively large vocabulary beyond individual digits and letters of the alphabet requires a limitation on the number of speakers which can be handled, or on the classes of speaker accents which can be accepted.

The recognition process for voice data entry involves the following major tasks:

- o Voice frequency spectrum analysis, in which a digit or word is analyzed for frequency and time rate of change
- o End of word detection, where the completed digit or word is detected and recognition processing begins
- o Time normalization, in which the word is broken into equal time increments

- Classification, in which the word is checked against stored patterns of acceptable numbers, digits, words, or short phrases, all of which must be predefined
- Output of selected reference pattern from memory to an output device, such as a printer or display

Equipment capable of handling several input channels (eight) is available in the price range of $60,000 to $100,000. It can handle only numeric information from a wide range of speakers.

In the early 1990s, we believe that voice data entry systems will be available in which two to four channels of voice input can be handled simultaneously. Any group of individual digits or alphanumeric characters and up to 300 preselected words can be recognized from a diversity of speakers at a cost in the range of $8,000 to $15,000.

Applicability to Navy Payroll Problems

We believe the use of voice data entry has little potential for contributing to new system solutions to the shipboard Navy military pay problem. While from a capabilities viewpoint it could be employed, we believe that keyboard entry of transaction information is much more desirable, will always be cheaper and will always be more flexible during the next decade.

G. AUDIO RESPONSE UNITS

Systems capable of providing a speech response through voice synthesis provide an attractive means of economical delivery of simple responses to inquiries directed to a computer's file storage mechanism. The most common use of audio response units today is in combination with the touch tone telephone to identify an inquiry and to deliver a response via the telephone instrument. This is common for credit card verification and for account balance information in the banking and financial industry.

The use of digital storage techniques for the individual phonemes or speech segments which must be brought together to compose an audio response is common today, allowing the storage of speech segments to be treated like any other data storage on magnetic disk, or in high speed memory.

Because of the widespread use of visual display devices, and the low cost for such CRT-based terminals, the manufacturing volume for audio response units is relatively modest and is predicted to remain so. Because of this, we do not see major reductions occurring in the cost of audio response units over the coming decade. Today's systems are typically capable of handling 10 to 20 simultaneous input and output channels and cost in the range of $200,000 to $300,000. We could visualize this capability being available for less than $100,000 by 1990. A device capable of handling only a few speech input/output channels is likely to be available by 1990 for $30,000.

Applicability to Navy Pay Systems

While it is quite conceivable that audio response devices could be utilized to allow inquiries to be made from either the central files at the NAVFINCEN or from the small business systems located at each major shore/shipboard facility, we do not believe that it would be desirable to make this information so easily available to any touch tone telephone. We suggest that it be made available only to authorized data terminal devices within the DO's jurisdiction. Because broad geographic public access is not desirable, we see little applicability of audio response devices to any attractive future Navy military pay system concept.

X

SOFTWARE AND SOFTWARE SUPPORT TRENDS

The purpose of this chapter is to outline those technological advances that may significantly impact the resources required to develop and implement advanced military pay systems involving communication-based interactive data processing systems.

A. HIGHER LEVEL PROGRAMMING LANGUAGES

There is a clear trend towards the use of higher level programming languages within both the telecommunications and distributed data processing environments. Since most of the system alternatives involve a substantial amount of telecommunications functions, we will deal with both classes of programming languages in this section.

1. Higher Level Languages for Transaction Oriented Processing

It appears clear that the COBOL language will remain the dominant language within the Department of Defense environment for at least the next five to eight years. However, it is also clear that this language is far from ideal for the programming of remote intelligent terminal devices or even microprocessor-based small business systems. COBOL is a relatively mature language and little additional increase in programmer productivity can be anticipated through its use. Further, because of the large reservoir of trained COBOL programmers, it is likely to be a minimum of five years before any of the newer languages can be employed on a broadly based program, simply because of the resistance which any new language typically encounters among those already trained (and paid) to be experts in COBOL.

2. PASCAL

PASCAL and its derivatives have been used extensively for telecommunications-based program systems. However, it is also finding increased application in the data processing world, particularly in microcomputer-based intelligent

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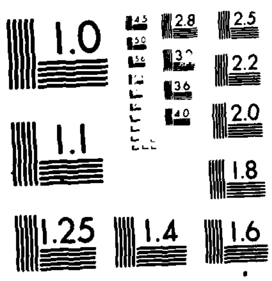

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terminals and small business systems as discussed above. PASCAL defines data structures in such a way as to be independent of the computer system on which the language is compiled. Like COBOL and other standardized languages, PASCAL will be highly transportable between computer systems. It is likely to be more portable than COBOL because of its machine-independent data structure approach.

Importantly, PASCAL lends itself to the use of an intermediate compilation language, the P code discussed earlier. This makes the language ever more portable between computers and aides in program maintenance, since only the higher level language need be updated rather than various assembled or compiled programs.

We fully expect that PASCAL its derivative will become the major programming language for intelligent terminals and small business systems by the late 1980s. Hence, consideration of its use early in the development cycle of decentralization to support military pay systems should be given serious consideration.

3. The C Programming Language

C has been developed by Bell Laboratories as a general-purpose programming language which is not a true high-level language, or one requiring a large compiler. Rather, it is a language featuring economy of expression, modern flow control and data structures capability, a richer set of operators than COBOL or FORTRAN, and a large number of defined data types. The C programming language has been associated with the UNIX operating system, operational since 1971 and used widely in the academic community and the Bell System. Its major features include:

- A hierarchical file system incorporating demountable volumes
- Compatible file, device and inter-process input/output
- The ability to initiate the synchronous processes
- A system command language selectable on a per-user basis

- Over 100 subsystems supported, including a dozen programming languages
- A high degree of portability

It includes a wide range of support programs to aid in debugging, utility programs, and device handlers. Its operating system is capable of being executed in microprocessors with as little as 20K words of primary memory supported by floppy disk. C was developed with the basic point of view that it would be transferrable between various computers and microprocessor systems, while the UNIX system must be recompiled and adapted to individual computers and microprocessors. This is a relatively straightforward process because of the intrinsic structure of the UNIX operating system plan for this form of portability.

An important benefit of the use of such an operating system is that it permits new technology microprocessors or new small business systems to be quickly and readily adapted to use the programming language standardized for the individual application--in this case the C programming language. We would anticipate similar structures to be developed for the PASCAL and ADA languages, where the operating system as well as the programming language itself are highly portable between computers, minicomputers, and microprocessors.

Both of these types of programming languages, i.e., PASCAL and C, are capable of dealing with data sets in the form of strings, link and tree structured lists, various types of record formats. Because of this rich variety of data structures allowed, a certain minimum size of microprocessor on-line memory is required to ensure that the entire data structure can be kept in memory. Further, in order to operate upon these data structures as a unit, future processors are likely to allow data structures to be addressed without regard to word boundaries.

4. Telecommunications-Oriented Higher Level Programming Languages

There is a clear trend towards the use of PASCAL-derivative languages for all forms of telecommunications switching equipment and telecommunications processors. The CCITT is developing a standardized form of PASCAL which is termed

"CHILL." CHILL is likely to be fully defined within 1980, the standard language for telecommunications processing and switching processors by 1985, and the major language employed in 1990. There appears to be agreement among most of the switching equipment manufacturers that a substantial degree of standardization of higher level languages for switching applications is absolutely essential in order to permit programmers to move from one developmental program to another, as well as to allow portability of programmers between switching manufacturers as their workload demands. Further, there is a clear acceptance of the fact that higher level programming languages of the PASCAL-type contribute substantially to programmer productivity and to improved documentation of programs once written.

There is also a general recognition that the <u>efficiency</u> of the final code structure developed from a program is relatively unimportant, compared to the investment of <u>manpower</u> resources to create the initial program. This is occasioned by the continuing reduction of the cost of memory and of the cost of executing constructions. Thus, the use of higher level languages is viewed as one of the few tools available to management to reduce the development costs and development time frame for major new programs.

B. PROGRAMMER PRODUCTIVITY IS KEY FACTOR TO FUTURE SUCCESS

The microprocessor revolution is giving rise to a projected severe shortage of programming personnel capable of providing the necessary software for the microprocessor industry itself--without regards to the actual applications programming requirement of the end user of these microprocessors. Recently the Chief Operating Officer and President of Intel Corporation indicated that without a change in the basic delineation between hardware and software in microcomputer and microprocessor systems, Intel would need close to one million software engineers by 1990, whereas the educational institutions will have turned out only tens of thousands by that time.

The important conclusion which Intel has drawn is that they must integrate at least the first few layers of software within the design and the silicon real estate of the microprocessor itself. They believe that application technology of microprocessors will be limited by the available manpower to perform the necessary application and file structure software over at least the next decade.

The Intel-defined experience in productivity indicates that software in assembly language can be written at ten lines of machine code per man day, or approximately 200 lines of machine code per man month. Their experience also indicates that higher level languages can be done at about four times the rate of assembly coding, or approximately 800 equivalent assembly language level instructions per man month.

C. SOFTWARE IMPLEMENTATION IN HARDWARE

An important trend of the 1980s, the beginning of which is already visible, is the integration of operating system software in processor hardware. Intel has recently announced their extended product lines in the microcomputer area for the decade of the 1980s.

The 8-bit microcontroller is used for peripheral control and other related tasks and represents the low-end of software integration into hardware.

The next level of complexity is the microcomputer class. These devices are based either on 8- or 16-bit word structures. They already exhibit many of the characteristics found in classical computer systems and may have registers of up to 60 bits. Data types may be either 8 or 16 bits.

The micromini class is more complex. It includes Intel's current top-of-the-line microprocessor, the 8086. Devices of this type are roughly equivalent to medium sized minicomputers of the PDP-11 type. The cost of software will outweigh the cost of hardware for this microprocessor. According to Intel, this is the first level of complexity where true integration of systems software and hardware will become necessary.

Intel is developing a complete operating system intended for this type of device. This operating system will have the basic functions in its inner parts, surrounded by I/O drivers in the next layer, a file system in the next layer thereafter, and finally, a data management system. Further, this operating system will include memory management functions, including segmentation of memory and facilities for the multi-user environment. This operating system, which is expected to become available next year, will further be modular, giving the systems designer the choice of selecting only the parts needed for particular applications.

As we understand, this operating system will be implemented initially in software for the Intel 8086. However, the requirements for the successor of the 8086 in the micromini class have already been designed into the operating system. The intention is to integrate the kernel of the operating system into

the CPU chip itself. Further, I/O drivers may be integrated into the special chips supporting individual peripherals as, for instance, into the chips supporting data communications.

The next higher level of complexity will be the micromaxi. This will be a more capable microcomputer, based on either 16- or 32-bit internal architecture. Here, an operating system similar to the micromini is envisioned but with the additional capabilities of virtual memory, more advanced addressing schemes, etc. The inner parts of the operating system will be integrated into the CPU chip itself. Further, the operating system will be able to support a variety of coprocessors which perform specialized tasks like mathematical routines, frame processing, etc. It is quite possible that higher language compilers will be implemented in silicon to augment the operating system of these devices.

The ultimate level in complexity envisioned by Intel for the second half of the 1980s will be the micromainframe. While the micromini and the micromaxi families will have upgraded instruction sets compatible with that of the present 8086, the micromainframe will be of entirely different design. This device is envisioned as a 32-bit processor on a chip. It will have no programmer-visible registers, and there will be no assembly languages for this machine. It will be programmable only in a higher level language, probably of the PASCAL or ADA variety. The complete operating system and language compiler is envisioned to be implemented in silicon, leaving only the application programs to the users. Further, this processor is likely to be able to fetch data strings of up to 64 bits. It further will report advanced record and record addressing modes, multi-programming and multi-processing in hardware.

D. IMPACT OF DECENTRALIZATION

The decentralization of processing and/or file access as anticipated in the military pay systems concepts for the 1990s will require several major changes in the system and software development activity in the Navy. Software development is largely centralized at NAVFINCEN, whereas systems planning is centralized in NFAC in the Washington area. Because of this split, the distribution of processing capabilities existent in the 1990 time frame will require facilities for the updating and configuration control of regional and shipboard data processing systems, as well as the software contained within intelligent terminal devices. Changes in any one of these sets of three programs may impact the other levels of processing, requiring a higher degree of modularization of software, and improved administrative controls for distribution of new generic software modules. It is not clear at this point how the distribution of programs to subordinate processing centers or intelligent terminals can best be done during the 1990s via one of the following modes:

- o Use of data communications to transfer the program to the subordinate processor
- o Physical shipment of the new program in a floppy disk or possibly in a bubble memory to the subordinate processor
- o Distribution of the program physically in an unalterable form in semiconductor memory of the read-only variety

Each of these approaches has advantages and disadvantages, and the overall trend for the early 1990s is not yet clear. We believe that any one of these methods is likely to be acceptable, with the most probable method that of physical distribution of floppy disk media.

E. OVERALL SOFTWARE TRENDS

The major factors affecting software trends from now until the early 1990s appear to be the following:

- o Requirement to increase productivity of system and application programmers
- o Incorporation of operating systems within the micro-processor design and hardware itself
- o Requirement for on-line interaction at data rates of at least 2400 bps or higher for program testing
- o Worldwide availability of data communication satellite channels permitting on-line access even aboard ship, with in-net store-and-forward capabilities
- o Reduction in significance in the cost of program storage and the imputed cost of execution time brought about as a result of VLSI technology advances
- o Use of generalized display driver modules which permit menu selection algorithms to be implemented in higher level languages and prompting aids for transaction recording, greatly reducing the required programming effort for specific data base access techniques
- o Generalized file management systems capable of dealing with large data bases without custom software develop ment

Another important development is the improvement in debugging techniques often associated with the compilers for languages such as PASCAL and C, where a substantial edit of the instructions can be accomplished prior to compilation. There is a clear trend toward the use of PASCAL and its derivatives for both minicomputer and microprocessor application programs for data processing and telecommunications applications. We forecast a significant demise in the use of COBOL for any form of decentralized processing, but a continuation of the use of COBOL for high level large scale data processing installations even in the early 1990s.

XI

SYSTEM CONCEPT A

CRT-BASED LOCAL TRANSACTION RECORDING

A. GENERAL SYSTEM CONCEPT

The major improvement in the military pay system offered by this concept is the provision of automated support to the formatting, editing and recording of each field transaction type, through the use of a keyboard visual (CRT) display with twin floppy disk drives.

The display device would be intelligent, allowing the various transaction formats to be called from local memory so as to permit payroll and pay-related actions to be recorded through prompted input. The intelligent display device would also be capable of performing editing on the information entered into each of the fields to ensure conformity to the transaction format.

The display would then record the information on removable disk media after making a copy of the total group of transactions for the day or week. The floppy disk would then be mailed periodically to headquarters for processing.

This system allows the LES to be distributed on floppy disk to the intelligent terminals aboard ship, where the information could be read out for inquiry purposes. It can also be utilized to assist in the preparation of field transactions by direct reference and/or copying of data contained within the LES.

Larger ships would have an on-board printer to prepare LES documents and checks. Smaller ships would receive the LES document and the LES floppy disk. Alternatively, a very inexpensive strip printer could be provided to smaller ships to assist in balancing operations.

B. FLOW OF TRANSACTIONS

The flow of transactions would be physically identical to the current flow except that transactions would be recorded shipboard in machine-readable form directly, and the media sent through the U.S. Postal Service for machine processing rather than prepared on OCR media. Similarly, the LES is distributed on floppy disks in all cases and in hard copy tabulated form to ships not equipped with a printer.

C. DATA BASE REQUIREMENTS

Essentially, the centralized MPR remains intact in NAVFINCEN. The only change is that the LES is distributed in machine-readable form directly to ships rather than being distributed in paper form. While this may be viewed as a data base requirement, it does not constitute a significant change from today's data base structure, since this information is currently being distributed for reference purposes in paper form. This system concept only requires that it be distributed in machine-readable floppy disk or diskette form.

D. TRANSMISSION SUPPORT

There is no electronic transmission support requirement under this system concept, but rather the U.S. Postal Service continues to be used for the inward flow of field transactions and the outward flow of LES documents to field activities. A modest reduction in postage costs could be anticipated.

E. MAJOR ADVANTAGES

The major advantages of this approach are as follows:

- A radical reduction in the number of incorrectly formatted or erroneous transactions, likely to less than 2%
- Although the U.S. Postal Service continues to be used and a one-week delay can be anticipated for this flow, the additional delay caused by the inability of the OCR scanner to read a document is avoided. The substantial delay associated with correcting erroneous transactions is also eliminated. Thus, the overall average time from a field transaction to its actual processing to the on-line system at NAVFINCEN is likely to be in the range of 8 to 10 days.
- The information is sent through the mails in machine-readable form which eliminates manual manipulation of individual pieces of paper. This will reduce the mail-room manpower requirement, eliminate the OCR document readers and document handling requirement, and provide the ability to immediately process the received field transactions at the NAVFINCEN Computer Center.
- Superior transaction control can be maintained, and an additional machine readable copy maintained aboard ship for at least one month pending successful receipt through the mails of these submissions.
- The LES document is made available either for shipboard printing, shipboard visual display access and use in transaction preparation, reducing DO and DK time for transmission preparation.
- The local transaction recording capability could be used for pay-related transactions and file reference. A floppy disk would be adequate to maintain both the skeleton pay record and the MPR for several hundred

shipboard personnel. Thus, one terminal would likely be required for each 400 to 600 personnel aboard the ship (plus backup terminal).

- The system reduces LES paper storage requirements through storage of floppy disks instead.
- This concept does not require any major changes in current transaction flow, or telecommunications support, and maintains the entire MPR in the central files at NAVFINCEN.
- System Concept A saves some DO and clerical time due to the reduced level of incorrect LES documents. Perhaps only 15% to 20% of the LESs would be unusable for immediate pay purposes.

F. MAJOR DISADVANTAGES

The major disadvantages of this concept are:

- The roughly one-week delay for mail delivery of field recorded transactions is not eliminated nor is the comparable time required for the dissemination of LES information to the ship. This means at least 15% to 20% of the LESs still cannot be used for pay purposes without override.
- Without maintaining all or most of the MPR within the intelligent display device, comprehensive editing of the input transaction is not possible, hence the error range is likely to remain at 1% to 2%.
- This system concept requires dual floppy disks or a large bubble memory aboard ship for on-line storage of transactions. We would anticipate either the use of Winchester disk drives or of a multiple-chip bubble memory for on-line storage, in addition to the floppy disk which would permit transactions to be recorded on a (mailable) removable media for transmission to NAVFINCEN.

XII

SYSTEM CONCEPT B

CRT-BASED TERMINAL SYSTEM

A. GENERAL SYSTEM CONCEPT

In this system concept, a CRT-based visual display device with substantial intelligence, and acting as a data terminal device, would be utilized aboard ship to perform all of the functions outlined earlier for local transaction recording. In addition, it would permit the elimination of the shipment through the U.S. Postal Service of the floppy disk or diskette by using electronic transmission through commercial satellite facilities.

We fully anticipate that commercial satellite facilities in the UHF and 10 to 14 GHz ranges will be available in almost all parts of the world's oceans in the early 1990s. It may actually be available much earlier than this, with the possible exception of some areas off the coast of South America.

However, we propose that under this system concept the CRT terminal also have access on an on-line basis to the MPR at NAVFINCEN, or at one of the shore-based facilities, referred to as the host processing centers, in the land-based data processing support anticipated under PASS II.

Transaction recording, however, would normally be done in an on-line mode and only under unusual conditions would the MPR be accessed from the terminal for inquiry purposes, with no direct modification of this record. Rather, any changes would be added as a normal transaction which would be edited through the NAVFINCEN computer prior to actually modifying the file.

B. FLOW OF TRANSACTIONS

There are two alternatives for the flow of field transactions into NAVFINCEN. Transactions would go by electronic communication over satellite circuits directly to NAVFINCEN or to the nearest host processing center associated with the shore-based payroll systems. Copies of the MPR could be maintained at these centers. These machines would support local CRT devices on the same basis as we are proposing for shipboard use, and if given some additional capacity, we are certain they could handle the shipboard transactions as well.

There is little substantial advantage in actually using such a decentralized access, particularly since satellite circuitry is to be employed. Utilizing the store-and-forward packet switched satellite network, which would be available in the late 1980s or earlier, could provide any necessary buffering of transactions prior to acceptance by the NAVFINCEN computer. The benefit associated with using the regional host processing centers is very marginal, since the cost of satellite circuits is basically insensitive to distance.

C. DATA BASE REQUIREMENTS

This concept proposes the entire MPR to continue to be maintained on one central computer facility at NAVFINCEN. Although the low cost of decentralized storage would permit the MPR to be maintained aboard ship, this concept does not include shipboard MPR storage for shipboard personnel.

Data communications access to the central processing facility would be required in any case to the on-line transmission of field transactions. It may well prove highly desirable to maintain a skeletal pay record, which might be viewed as an extended LES, which is periodically distributed to the shipboard terminal equipment for ready reference and wartime pay procedures. However, it appears necessary to maintain the integrity of the MPR through the continuation of transaction-related changes, rather than transmission of the entire modified MPR between the ship terminal system and the central processing system.

D. TRANSMISSION SUPPORT

This system concept will require a modest amount of telecommunications support to allow the transmission of completed transactions from the ship to NAVFINCEN, and for the transmission of inquiry response, LES or skeletal master pay records from the Center to the ship terminal system.

Assuming an average of 500 personnel aboard a typical Navy ship equipped with a CRT-based terminal system, four transactions per month per person, and 40 characters per transaction, a total of two-thirds of a million bits per month would be transmitted from the ship to the shore-based facility. At 2400 bps transmission rate, this would involve less than five minutes of total transmission time during the month.

For the transmission in the reverse direction, assuming 500 personnel aboard ship, and an LES or skeletal master personnel record containing 100 characters is distributed once every two weeks, a total transmission requirement to each ship of approximately 800,000 bits per month would be required. At 2400 bps transmission rates, this would require approximately seven minutes of transmission per month. At 1200 bps, it would require approximately 15 minutes per month.

Assuming 600 total ships equipped in the Navy, the total minutes of usage into NAVFINCEN at 2400 bps would be less than 15 minutes per ship times 600 ships, or 150 hours per month. Thus, assuming the transmission were done only on an eight hour per day basis, the entire fleet could be served with a single voice-grade communication line operating at 2400 bps for the pay-related data.

E. MAJOR ADVANTAGES

The following are the major advantages accruing as a result of implementing Concept B:

- On-line editing of all transactions against the most recent LES or skeletal MPR stored locally is done, as well as other format and range limits applied. This will reduce the overall error rate to less than 1% in LES pay amounts.
- The ability to inquire into the MPR in those instances where transactions require access to this more comprehensive record reduces errors.
- Eliminates the delay associated with the U.S. Postal Service in the flow of transactions from ships to NAVFINCEN and in the flow of LES information to the ships.
- The MPR is maintained in NAVFINCEN and field-modified only via authorized transactions.
- On-line access for problem resolution is also provided from NAVFINCEN to ships via electronic message service provided in the terminal system.
- Substantial savings in mailing costs will accrue.
- All OCR document flow, reader equipment, and support personnel are eliminated by this approach, as they are also with System Concept A. This should result in sizable personnel and equipment maintenance charges offsetting a major portion of the cost of the distributed CRT-based terminal systems. The payroll system basically becomes paperless and the error rates under System Concept B are likely to be less than 1%. The MPR should be up-to-date within a maximum of one day's transactions, if several lines are provided to support the distribution of LESs immediately prior to the pay dates.

F. MAJOR DISADVANTAGES

The major disadvantages seen for System Concept B are:

- The requirement for the use of commercial satellite facilities, with additional costs averaging approximately $45,000 per month, at anticipated rates.
- A modest vulnerability of the system to wartime conditions where the international commercial satellite might be temporarily removed from service through excessive atmospheric ionization, or semi-permanently interrupted through the use of a "killer" satellite. We believe that the likelihood of even wartime conditions giving rise to the destruction of a commercial satellite service is remote, since the same satellite could be used by several parties to the conflict.
- The system requires some rotating storage aboard ship, likely a Winchester disk, but does not require a removable disk mechanism, which is substantially less reliable.
- The system would require somewhat greater training of the shipboard DO and his support staff than would be required for System Concept A.

XIII

SYSTEM CONCEPT C

AUTOMATION OF PAYROLL/CASH DISPENSING/

SHIP'S STORES' TRANSACTIONS

A. GENERAL SYSTEM CONCEPT

System Concept C employs an advanced shipboard minicomputer to support the following major functions:

- o One or more visual display terminal devices
- o One or more automated checkout machines at the ship's stores
- o Cash dispensing equipment
- o On-line storage for all necessary transactions and LES/skeletal military pay record
- o Data communications
- o Pay computation and check printing

The concept here is to be able to provide significant additional services to Navy personnel, and to reduce the requirement for shipboard cash by provision of debit accounting cash dispensing equipment aboard ship and as debit accounting for ship store transactions.

Concept C provides a CRT visual display terminal system, but has a minicomputer capability aboard ship which will also support the additional automated checkout terminal, and optionally, the cash dispenser.

A personal identification number (PIN) for all Navy personnel as well as a Navy credit card must be used together in order to activate the cash dispenser aboard ship. The Navy credit card would also be used for ship's stores' transactions. We do not assume that all ships would be equipped with the automated checkout and cash dispensing functions, but rather only the larger ships where it could give rise to actual personnel billet savings. This might mean a maximum of 100 to 200 ships in the Navy.

B. FLOW OF TRANSACTIONS

The flow of pay-related field transactions would be identical to that of System Concept B. In addition, transactions in ship's stores' would be handled in the onboard minicomputer by allowing draw down on an amount paid into the debit account for a member (or his entire pay), which is kept as a control within the minicomputer system. In the same manner, the cash dispensing equipment aboard ship would utilize draw down against the amount made available for short-term savings.

Clearly, the minicomputer would have to store a debit and available balance amount for each of the ship's personnel, together with his PIN and authorized credit card number. We would visualize this being stored in a Winchester-type disk. We see no requirement for the ship's stores or cash dispensing transactions to be communicated beyond the ship itself, unless there is some resulting debit amount when a person leaves the ship, or in some way owes the ship's DO money.

C. DATA BASE REQUIREMENTS

The data in NAVFINCEN would remain the same under this concept, but as in Concept B, the LES and/or the skeletal military record would be maintained on-line to the shipboard minicomputer. In addition, available balance, transactions since the last pay period, PIN, and Navy credit card number need to be stored for each member. We would visualize a printout of each pay period of the individual transactions and the date of the transactions for both cash dispensing and ship's stores' purchases, as well as any allotments made to the debit account, or direct payments to it. These would be provided to each of the ship's personnel who had any transactions of this type for the pay period. It would appear highly desirable to totally eliminate the pay line by utilizing the cash dispenser with automated crediting to the member's account of the amount due each pay period. However, this may succeed only if gradually phased-in.

D. TRANSMISSION SUPPORT

This system would require the same amount of transmission support as System Concept B, which assumes approximately 15 minutes of transmission per month per ship, or roughly 9,000 total minutes of transmission time at 2400 bps to serve the entire application requirement. An anticipated cost of $5 per minute results in $45,000 per month total communication line costs, exclusive of satellite terminal and modem amortization.

E. MAJOR ADVANTAGES

The major advantages of this approach are as follows:

- This approach has all of the advantages of System B.
- 24-hour availability of cash to all on-board personnel
- Substantial reduction of waiting time in pay line
- Some reduction in the working hours required for the DO and associated personnel
- A reduction in the number of manhours required of ship's stores' personnel and check-out time for members
- Provides ship's stores' services to personnel even though cash may not be available aboard ship for such transactions, particularly while in foreign ports, or under emergency conditions
- More productive work per day out of each member, through elimination of wait-time in various lines to obtain cash after pay periods, or to obtain money orders in order to protect cash prior to expenditure
- Amount of cash on-board is lower, hence equivalent interest would be saved on the difference

F. MAJOR DISADVANTAGES

We see the following major disadvantages of System Concept C:

- The automated cash dispensers are relatively large and heavy machines taking up valuable floor space, likely at least 10 to 15 square feet.
- The machine also increases the gross displacement of the ship by roughly 5,000 pounds.
- The cash dispenser is relatively expensive ($15,000/ minimum) compared to the other automation elements.
- Spare parts supply and maintenance support must be provided for still another type of electromechanical equipment on board.
- Failures in the cash dispensing equipment, which average one per 1,000 transactions, will cause some additional time on the part of the DO to clear.
- The existence of the cash dispenser may initially invite pilferage attempts and therefore increase security requirements. However, the device could likely be placed within sight of areas normally under surveillance.
- The system requires that the Navy credit card be re issuable aboard ship, or at least within the task force.
- This approach is clearly suitable only for larger ships, in the size range of heavy cruisers, carriers, etc.
- The individual may have some problem keeping track of his available account balance, since he will be using his balance for numerous small transactions at ship's stores, unless point-of-sale terminals print out balances.
- The capital investment requirement is roughly double that of providing automated support only to the payroll transation recording and communication capability.

XIV

SYSTEM CONCEPT D

FACSIMILE TRANSCEIVER APPROACH

A. GENERAL SYSTEM CONCEPT

The thrust of this system concept is the use of facsimile equipment for the transmission of OCR documents prepared on-board and the receipt of LESs from NAVFINCEN through the facsimile receiver. This eliminates the one week or more delay in the flow of transactions through the U.S. Postal Service.

The use of a facsimile transceiver aboard ship to transmit the OCR documents appears to be a feasible approach for implementation even before the early 1990s. Facsimile equipment is undergoing radical improvements as the trend of commercial enterprises to eliminate the use of U.S. Postal Service for high priority correspondence processes. Development is being stimulated in the Far East where ideographic characters, not easily amenable to normal data transmission approaches, are employed.

We would anticipate that all transactions would be prepared in roughly the same type of form as in an OCR document for transmission to NAVFINCEN via satellite communications. Importantly, digital compression would be employed to radically reduce the bandwidth requirement, and automatic scan control would limit the areas of the document scanned by the facsimile reader, based upon simple coded markings on the page.

The facsimile transceiver could also be used to receive the LESs from NAVFINCEN, again utilizing digital compression of the facsimile image to reduce the bandwidth requirements such that a document could be sent in under one minute using 2400 bps circuitry. Similarly, administrative messages could be prepared on the typewriter, and sent by facsimile to NAVFINCEN for action and vice versa.

The format for the recording of transactions on documents likely will have to be modified to allow multiple transactions to be entered on a single page for items beyond diary entries. Further, we believe that with this approach, it should be unnecessary to report the actual amount paid, because of the increased speed and accuracy of the centralized record. We believe that the amount paid should be reported only on an exception basis, rather than for all personnel.

We would also suggest that this concept would be totally viable with direct input of the facsimile document image to the advanced OCR equipment, without creating a paper image at the receiving site. Temporarily, the incoming digital image data would be stored on magnetic tape to assure that there is backup for the ICR function.

Further, we would suggest that as each transaction is read by the ICR, the MPR for the Navy member be made available to the ICR computer, such that possible misinterpretations or edits can be performed on-line. It this way, necessary retransmission could be immediately requested if the information is not fully readable or inconsistent with the previous MPR.

Importantly, the information sent by facsimile image would not include the form, which would be printed so that it is not read by the facsimile scanner. Only the information entered on the document would be transmitted. New digital compression techniques implemented in the facsimile transceiver may actually perform some of the early functions of image character recognition. In this context, it is desirable to use the same supplier for the facsimile transmission equipment, or at least of the digital compression module for the facsimile transmission, as is used for the ICR computer software.

B. FLOW OF TRANSACTIONS

The flow of transactions between ships and NAVFINCEN, as well as between shore facilities and NAVFINCEN, would remain essentially the same as today. After typing an OCR document for transmission, it would be sent via facsimile (digitally compressed) to NAVFINCEN. It may well prove desirable to perform the facsimile scanning function separately from the actual transmission, so that buffering on a floppy disk is accomplished, in order to minimize the amount of transmission time employed. Where only a few lines are used on a page, significant transmission time may be saved through use of appropriate coding on the document indicating to the reader what portion of the page should be scanned.

U.S. Postal Service Still an Alternative

Some of the documentation in the pay system is not time critical. Where facsimile equipment printers are broken down and cannot be repaired on a timely basis, the OCR documents could be sent through the U.S. Postal Service, and similarly the LES distribution could be made to the ships via U.S. Postal Service for these special situations.

Present Equipment Still Usable

Under this system concept, the OCR type font typewriters now used could continue to be employed for the production of the documents for facsimile transmission. In fact, since the old procedure and the new procedure use the same initial OCR typewriter, a very convenient conversion process would be encountered.

C. DATA BASE REQUIREMENTS

Under this concept, the MPRs would be totally centralized at NAVFINCEN for ship and shore facilities. The major change proposed in this system concept is only in the method of document transmission, which would be more or less on an immediate, or at least on a daily basis.

As indicated earlier, it may be desirable to accumulate digitally compressed facsimile information, such that a larger volume of it can be transmitted in order to achieve economies in communications. In this case, a floppy disk would be required in the facsimile terminal, together with microprocessors as a control, to accomplish this buffering function.

Current OCR equipment would continue to be used during the conversion period to accept OCR documents sent from ships not yet equipped with facsimile transceivers until new OCR equipment, capable of accepting direct digitally-compressed facsimile image information is available. Importantly, the transport of paper would be eliminated under this concept, since only the image is transmitted to the ICR. We believe that this will increase the throughput of the OCR equipment even though there may be some increased error rates due to distortion of the characters by the facsimile transmission.

D. TRANSMISSION SUPPORT

Utilizing comprehensive digital compression techniques on standard-sized pages containing only alphanumeric information, relatively high-quality facsimile transmission of such pages can be accomplished in under one minute at transmission speeds in the range of 2400 to 4800 bps, in the early 1990s and before. Since the image information is converted to digital form for compression, if desired, encryption techniques can be applied prior to transmission of the image information.

We assume the use of UHF radio or 10 to 14 GHz transmission facilities to commercial satellite systems to provide the transmission support for this system approach.

Since we believe that this system approach will eliminate the requirement for reporting actual pay disbursements, we will assume two to three transactions per month per Navy member aboard ship. With an average of 500 members aboard and an average of five transactions per page, the average ship would require 300 minutes of transmission per month, or approximately 10 minutes per day to accomplish this function of inward flow of transactions. Assuming only two LESs per full-sized page, the monthly transmission of LESs would require 250 minutes per month, or again, 8 to 10 minutes per day. We believe that this amount of transmission is reasonable within the commercial satellite communication tariffs anticipated early in the 1990s. The total communication circuit costs monthly would be in the $1.8 million range ($21.6 million annually). This is accomplished with a relatively low cost terminal and little retraining or change in existing procedures.

E. MAJOR ADVANTAGES

The major advantages of System Concept D are as follows:

- A minimal amount of equipment changes will be required to implement facsimile transmission. The continued use of the OCR typeface and a modification of the existing OCR readers, or implementation of two to three additional computer systems for recognition purposes (without any document transport mechanisms) would be required, in addition to the facsimile transceiver aboard ship, at shore facilities, and satellite-earth station facilities aboard ship.
- The U.S. Postal Service could still be used for non-time-critical document flow, for backup in case of facsimile terminal failure, and for the conversion transition.
- Direct daily transmission from ship and shore facilities to NAVFINCEN and vice versa will eliminate the mail delay and reduce the error rate in the LES to 1% to 2%.
- Advanced, reasonably-priced ($5,000) facsimile transceiver equipment with digital compression will be available.
- The basic transaction information need be recorded only once on the OCR typewriter, and without manual changes or movement of paper beyond the ship, reformatted.
- Transmission can be made on an unattended basis, which will expand the transmission facility usage and improve cost effectiveness. Spread over the various time zones of the world, this could reduce the total number of incoming lines required from the satellite earth sation to NAVFINCEN and reduce the total number of ports required on the ICR on-line computer system.

- Eliminates essentially all paper flow relating to transactions and LES data. NAVFINCEN personnel savings and OCR document transport equipment is also eliminated.
- Outgoing LES documents could be sent directly from digital alphanumeric form to digital facsimile.

F. MAJOR DISADVANTAGES

The major disadvantages of this approach are:

- The accuracy of character recognition from the digitally-compressed facsimile image may be somewhat lower than would be encountered with data transmission from a keyboard data entry device. This means that immediate retransmission requests might be generated to ensure error free transmission of documents.
- The OCR document would have to be reformatted, and the form printed in such a manner that the transceiver would read only information entered by the OCR typewriter through use of specific control markers for scanning control purposes.
- An investment of less than $5,000 per ship will be required for the facsimile transceiver with digital compression, possibly with some intermediate buffer for transmission purposes.
- Unless digital storage (buffering) of several pages is employed, the use of transmission facilities will not be optimum, particularly for satellite transmission, since relatively small block sizes must be employed together with forward-acting error control to ensure accurate reception.
- This approach does not provide any automation of the check preparation function and does not assist in the on-board accounting functions necessary for cash control, etc.
- Handling of inquiries would be much slower than where data terminals are used.

XV

SYSTEM CONCEPT E

COMPLETE SHIPBOARD COMPUTATION OF MILITARY PAY

A. GENERAL SYSTEM CONCEPT

System Concepts E and F depart totally from the previous concepts in that they put primary military pay computational responsibility aboard ship for shipboard personnel, rather than with NAVFINCEN. They use an advanced minicomputer/microcomputer system to support the following functions:

- o One or more visual display terminals for transaction recording and dinquiry to local pay records
- o On-line storage of the MPRs of all shipboard personnel
- o Data communications capability via satellite facilities for pay transactions
- o Check printing on-line printer
- o Shipboard preparation of LESs

Concept E also includes the ability to support automated checkout machines at the ship's stores and cash dispensing (automatic teller) equipment aboard ship, but these are not essential to the concept.

One of the most important requirements of this approach is the ability to store some 200,000 to 300,000 instructions anticipated as necessary in order to make the pay calculation from the MPR. Importantly, it also assumes that the current pay program, written in COBOL, be totally reprogrammed in a language more suitable for a mini/microcomputer system (ADA or PASCAL). We believe, based upon other payroll systems of similar complexity, that without the necessary accounting and management report facility currently available in the NAVFINCEN computer, the 200,000 to 300,000 instructions would be adequate. Importantly, a $3 to $5 million investment is likely to be necessary to convert that existing program or an updated version of it for shipboard use.

The use of a portable electronic pay record with this concept would likely be most useful (System Concept F), but alternatively, when personnel move to or from the ship, they could be given a floppy disk containing their entire MPR in automated form for delivery to their next post.

Control of the MPR record could still be maintained by NAVFINCEN. Permanent updating of the record would occur only after thorough edit by NAVFINCEN of all transactions affecting this permanent record.

The concept would be to keep the MPR aboard, to make changes to the MPR locally in the shipboard computer system, and to create the checks locally each pay period. Further, the required LES could be generated locally and given to the Navy member.

After each pay period, or whenever satellite facilities could be made available, transmission would be made from the shipboard computer system via commercial satellite to NAVFINCEN to update the accounting records and the central MPR used for budgetary planning purposes and allotment processing. Thus, transactions reported to NAVFINCEN would be changes in military pay status and the actual payment made. It would also include transactions indicating to NAVFINCEN what allotment checks should be provided, with such reporting likely on exception basis for allotments. Thus, allotments are pre-authorized, but can be changed in the field and immediately reflected in the field pay computation.

Most importantly, the current status of all factors affecting pay would be known and used in the field pay computation, eliminating the requirement for the field audit of the LES.

B. FLOW OF TRANSACTIONS

The flow of pay-related transactions from the field would be initially into the shipboard computer system for updating of the local files to be used for pay computations, then to NAVFINCEN on a periodic basis. In this way, should transactions in the ship's stores and/or automated teller equipment be automated on some ships, the member's pay could be debited with the appropriate amount prior to issuance of payment. In this manner, better control could be kept of debit balances against pay about to be issued, if this type of service were desired to Navy members.

It would appear that a large Winchester-type disk and a floppy disk would likely be required to support this form of system concept aboard each ship.

The primary information flowing from NAVFINCEN to the shipboard computer (via commercial satellite facilities) would be:

- Transmission of MPR for new personnel
- Changes in the pay software
- Possibly actions from BUPERS affecting the MPR

All of these are considered to be low volume; the updated generic pay computational software could well be distributed via the U.S. Postal Service in the form of a floppy disk.

C. DATA BASE REQUIREMENTS

The data base required aboard ship would be essentially the entire MPR of each person aboard ship and the approved military pay software program and the capabilities to accumulate debit accounting information if automated shipboard store checkout equipment and/or cash dispensing equipment were provided.

Even for the largest capital ship, the data base requirements are not excessive and still could be accommodated within a system costing less than $25,000 in the 1990 time frame for the complete system if purchased in quantity.

Assuming an MPR averaging 7,000 characters, even for a large ship with 5,000 personnel aboard, only some 40 million bytes could be reequired in disk storage capacity or one larger Winchester disk drive.

D. TRANSMISSION SUPPORT

This system requires the reporting of all status changes and the actual pay made, from the ship to NAVFINCEN twice monthly as a minimum.

Assuming an average of 500 personnel aboard a typical Navy ship equipped with this system and assuming four transactions per month, of which two are actually the local payment made transactions, and assuming 40 characters per transaction, a total of two-thirds of million bits per month would be transmitted from the ship to NAVFINCEN or other shore-based computational facility. At 2400 bps transmission rates, this would involve less than five minutes of total transmission time during the month for each ship. Assuming 600 ships, this would require approximately 3,000 minutes per month or 50 hours per month of transmission.

For this system concept, there is little flow of information from NAVFINCEN to the ship particularly while at sea. There should be few, if any, inquiries from the ship to NAVFINCEN, since the complete pay record is maintained locally aboard ship. Thus, in contrast to system concepts discussed earlier, the total amount of communications per month is only about one-half of that required by other concepts involving transmission of the LES to the ship.

Thus, the monthly recurring circuit costs would be in the $15,000 to $20,000 per month range.

E. MAJOR ADVANTAGES

The following are the major advantages accruing as a result of implementation of System Concept E:

- All OCR-related equipment and support personnel are eliminated at NAVFINCEN.
- The entire automated MPR is available for local inquiry, local updating, and local use for pay computational purposes aboard ship. This eliminates delay in answering members' questions concerning their pay record, a sizable amount of communication between the ship and NAVFINCEN, and should improve members' morale relating to pay amounts substantially.
- The shipboard computed pay amount should essentially always be correct or easily modifiably locally if the member finds some data base or transaction error.
- Essentially, a duplicate MPR is maintained at NAVFINCEN, and if the electronic portable pay record is employed, allows the record to be permanently altered only on transmission of an encryption key which permits the electronic pay record to be written locally. We visualize this might be done only when personnel leave the ship for transfer to other facilities.
- Mailing costs are eliminated, and pay-related paper handling at NAVFINCEN is also eliminated.
- All OCR document flow, the document readers and the support personnel required by this current approach are eliminated, with net savings anticipated despite the cost of satellite communications, and the amortization of shipboard equipments.
- The member can take his current military record with him to his next station when he leaves the shipboard environment. This can be either in the form of the updated electronic pay record or even in the form of a floppy disk.

- The system easily allows incorporation of automated cash dispensers or debit accounting from the ship's stores to be incorporated at any time and assures that accurate debit accounting is performed prior to payment of the member.
- Wartime military pay support to Navy members is outstanding in this concept.

F. MAJOR DISADVANTAGES

The major disadvantages seen for System Concept E include:

- The requirement for the use of commercial satellite facilities with costs running in the range of $15,000 to $20,000 per month--but significantly less than that required for most other system concepts explored involving greater NAVFINCEN involvement in the pay computation.
- A high capital investment per ship, and a high desirability of converting all ships and shore facilities to this same form of payment procedure, since otherwise the OCR equipment must be maintained at NAVFINCEN. While this is not an absolute necessity, we believe that personnel serving aboard ships with this kind of facility would be extremely unhappy when moving to a ship served by the OCR-based pay methodology.

  The total capital expenditure assuming a cost per ship (excluding earth station) of $25,000 for some 600 Navy ships would be $15 million for the hardware and an additional $3 to $5 million for the conversion of the pay program for shipboard use or a total capital expenditure in the range of $20 million.
- Updating or maintenance of the military pay program would require periodic distribution of the program to all ships. If this could not be accomplished during wartime procedures, the ships would have to continue to use their old programs, unless long blocks of time could be found for transmission of the new program via satellite. We would not recommend this, however, as a standard practice, but only as an emergency backup system. Typically the program could be disseminated on floppy disks via the U.S. Postal Service for implementation on some fixed future date.

- This system concept would require the greatest amount of shipboard DO and staff training of any of the concepts explored, since they have total responsibility for the military pay system. However, we believe that operationally the system would be as simple as other procedures requiring shipboard automation of transactions. Only the facsimile approach is likely to be significantly simpler and easier.
- This system requires a duplicate set of MPRs to be maintained at NAVFINCEN to be used for military pay accounting, management reports and other controls. Because communications might not always be possible to be completed on the scheduled basis, these reports may temporarily be not totally current.
- NAVFINCEN would be dependent upon transmissions from the ship to ensure the adequacy of their fund accounting records. Under wartime conditions, these records may be slightly out of date, but since a complete set of records, excluding the last days or weeks of transactions, are available at a centralized facility. Overall military pay accounting records are likely to be more accurate than those of today.

XVI

SYSTEM CONCEPT F

PORTABLE ELECTRONIC PAY RECORD AND SHIPBOARD PAY SYSTEM

A. GENERAL SYSTEM CONCEPT

This concept takes advantage of the exceptionally small size and weight of modern VLSI semiconductor memory and microprocessor technology by storing the complete member payroll record or a sufficient part of the record for an individual, in a portable, thin pocket calculator-sized electronic unit. This can be carried by the individual from ship to ship or from ship to shore, thus the record is always available for local or remote computation of pay. This device could be updated, but only with access to an encryption key stored in the central NAVFINCEN facilities. The record has the identification card and photograph of the member laminated in the device. This concept otherwise is very similar to System concept E.

Concept F assumes that there would be a small business system aboard ship and at each shore facility capable of accessing NAVFINCEN to obtain the necessary encryption keys for updating the individual pocket-sized payroll record, as well as to report actual disbursements made and transactions affecting pay. Thus, each ship and shore facility would have the capability of generating the correct amount of pay to be issued locally and would have local access to all of the factors making up local pay for inquiries by Navy members.

Since there is some probability of loss of this portable record, we would assume that a complete master record would be contained in centralized files at NAVFINCEN for ready access.

We would anticipate that the pocket calculator-sized electronic payroll record (or even possibly thick credit card-sized record) would be given to the DO upon being assigned to a given ship or shore facility. These would then be retained by the DO, read out into the local small business system with data terminal capabilities, then retained in an appropriate safe. Alternatively, this device could be used in lieu of a credit card to activate an automatic cash dispenser or debit accounting at the ship's store's automatic check-out terminal.

B. FLOW OF TRANSACTIONS

Transactions affecting a member's pay would still be keyboarded on a CRT data terminal device (as a part of the shipboard small business computer system) with sufficient intelligence to provide a broad range of editing services to the operator. A completed group of transactions would be periodically communicated via commercial satellite facilities from the ship or shore facilities to NAVFINCEN where further editing and updating would take place. Those transactions affecting the pay record for the individual would be verified and the encryption key, together with the transaction, retransmitted to the field installation to update the pocket portable electronic payroll record of the member on a periodic basis.

The actual pay calculation would be made at the ship computer facility, and the necessary member paycheck cut by the small business system at the field or ship facility. NAVFINCEN would continue to make all allotments and payments other than directly to the member.

This concept should eliminate the need for an LES created by NAVFINCEN and probably eliminate the need totally. If the DOD guidelines were not revised to eliminate the LES, it could be sent by mail from NAVFINCEN to the members essentially for thier use only, and would not be used by DO for any payroll function. Alternatively, the LES could be produced locally by the shipboard small business system, which is the approach most likely to be taken.

C. DATA BASE REQUIREMENTS

The MPR on a Navy member averages approximately 8,000 bytes. It would be necessary to store all or some portion of this in the member's pocket electronic payroll record. By the early 1990s, this amount of storage could be contained on one VLSI chip, possibly with an additional chip being included in the electronic payroll record as a microprocessor to ensure the data security of this record.

We also assume that identical information is stored in the small business computer system at each DO's facility, read out from the electronic pay record upon assignment of the Navy member to that facility.

In addition, the complete payroll record would be maintained at some central facility, probably NAVFINCEN, where on-line access would be provided. We would recommend that no updating of the member's electronic pay record be permitted prior to having any transaction affecting the pay record first validated by the NAVFINCEN computer, which would then retransmit in the appropriate format updating information, together with an encryption key good only for a single updating, to the appropriate facility to modify the member's electronic pay record.

D. TRANSMISSION SUPPORT

In addition to the traffic already discussed for the flow of transactions between the field facilities and NAVFINCEN via commercial satellites, we would add the necessary periodic (weekly or biweekly) updating of the member's electronic pay record and encryption key from NAVFINCEN to the shore facility. However, because the member's pay record is stored locally, we would anticipate a substantial reduction in communication requirements or inquiries. Administrative message flow relating to pay would almost be eliminated. For planning purposes, we believe that a doubling of the total transmission time for transactions only (excluding LES transmission time), would be adequate for the overall flow of information on a biweekly basis. About 100 hours per month of 2400 bps communication would handle the entire fleet under this concept, or a monthly circuit charge of $30,000.

E. MAJOR ADVANTAGES

The major advantages of this approach are:

- Total elimination of OCR-related equipment and personnel at NAVFINCEN.
- An ability to locally generate the correct amount of pay during emergency or wartime conditions since the entire pay record is stored in the local facility computer, as are those transactions which affect pay since the master record was last updated at the central site.
- The entire pay record is available for local inquiry, and does not require communication support for such inquiry functions. This reduces the necessity for disk access capability at the central site significantly.
- The pay record is available in electronic form to move between Navy facilities through the member's being responsible for bringing his electronic pay record with him. This has the advantage that no delay is encountered by the Navy member in receiving the correct amount of pay, and incorrectly issued pay amounts are not made.
- Because the entire pay record always follows the individual, the discrepancies often found upon discharge of members, and the subsequent loss of funds would largely be eliminated.
- All transactions during non-emergency/wartime conditions would be validated by the NAVFINCEN computer prior to being reflected in the permanent central record and the personal electronic payroll record.
- Essentially System F provides all the advantages of System Concept B and can be implemented in the same form as System Concept C to provide for the activation of automatic cash dispensers and automated ship's stores' check-out terminals.

- System F gives members the ability to purchase in any Navy facility up to his available balance without a credit authorization system needed.
- Elimination of all transaction and LES paper flow to and from ships.

F. MAJOR DISADVANTAGES

The following major disadvantages can be identified for this system concept:

- The overall ship-shore communication requirement is roughly doubled versus that of System Concepts B or C, with the exception that we would anticipate a significant reduction in administrative inquiries handled either by data message or mail concerning the member's pay record. Further, the shore-ship communication of LES forms is eliminated.
- The possibility of the member deliberately losing his personal electronic pay record would require that these pay records be capable of duplication from the MPR at NAVFINCEN. The delay in receiving such a duplicate may affect one pay period of the member, but we believe it justifiable that the member not be paid if he loses his electronic pay record. He does not hold the electronic pay record, unless it is used for shipboard cash dispensing and charging at ship's stores; in this case, it acts as any other credit card to deny credit availability if the card is lost. Reported losses can be used to immediately restrict any further purchases or cash dispensing on the member's card.
- This system concept requires complete storage of the member's record in three places:
  - the central files at NAVFINCEN
  - the member's personal electronic pay record
  - the ship- or shore-based small business system utilized by the DO for actual payroll computations.
- This system approach requires that the payroll computation program be redone for implementation aboard a ship-based computer. This is likely to be a costly one-time conversion and will require an estimated

200K to 300K in instructions, or 400K to 500K bytes of storage in the field computer system for the payroll computational program. However, in early 1990 memory prices, this should likely represent less than $5,000 incremental cost in each of the field computer systems for this form of storage.

- Unless automated check-out and debit accounting are utilized both aboard ship and at Navy shore facilities, a normal credit card could just as well be used for the debit purchase function.

XVII

REJECTED SYSTEM ALTERNATIVES AND REASON FOR REJECTION

1. Give Each Individual a Computer Capable of Storing His Entire Personnel Record and Computing his Pay

We reject this on the basic premise that it would be too easy for the individual to lose, destroy or modify his record. Secondly, there would be no realistic opportunity for centralized control of expenditures, or expenditure forecasting. Further, it would delay necessary fund accounting, unless a totally-duplicated record were maintained. Further, there would be no means of updating the information stored in the personal computer without going to a facility equipped with a computer for such modification. If this were necessary a more centralized computer onboard ship might just as well do the actual payroll computation and create disks.

2. Alternative Using a Standard Navy Credit Card for Shipboard Purchases

This approach does not use any advanced technology and this would not serve to upgrade Naval pay systems. It is a convenience to members only.

3. Total Elimination of Navy Finance Center Pay Records

The storage of these records only aboard ship would be subject to either shipboard computer failure (since we do not wish to have duplicated computer systems aboard ship) or damage to the shipboard computer due to accidents, military action, or fire. Further, accrual forecasting of pay and allotment issuance need to be done from a more centralized facility than a ship itself. We consider that it would be totally unreasonable to issue allotment checks from a shipboard computer system, for example.

4. Electronic Funds Transfer for Active Members to Their Banks

We have eliminated this possibility because of the difficulty in controlling bad checks which would be written aboard ship against the accounts of individuals held in a wide range of land-based banks. This approach, however, certainly could and should be employed for shore-based personnel and for retired personnel.

It is important to recognize that the allotments made by shipboard personnel computed at NAVFINCEN should be distributed by EFT, even though the amounts paid directly to the Navy member are not paid in this manner.

5. Improved OCR Readers

OCR documents could continue to be used if improved. This approach is rejected because we are attempting to eliminate the time delay resulting from use of the U.S. Postal Service. Additional investment in OCR equipment, we believe, is not warranted since it will achieve only a modest improvement in the error rate for the OCR readers.

XVIII

CONSEQUENCES AND IMPACT OF ADVANCED TECHNOLOGY ON ALTERNATE METHODS OF NAVY PAY

The purpose of this chapter is to provide a summary statement of the impact and key opportunities made available by advanced technological development forecast to occur in the next decade in the field of information technology as it might apply to the shipboard military pay requirement.

A. GENERAL CONCLUSIONS

While the cost and size of semiconductor memory and microprocessor capabilities are such as to double the capacity/processing throughput within each three-year time frame, the significance of these developments to the shipboard application of situations for military pay are extremely limited. Small data processing systems including visual display devices aboard ship will be smaller, more reliable, and less expensive than in the early 1980s.

However, because of the requirement for centralized financial control, the ability to perform the actual pay computation solely aboard ships with such small business systems is not desirable from a system concept viewpoint. There is some question as to the size of the necessary program to perform the actual pay computation, and hence the cost of the required storage on-board to keep the program on-line to the small business system, but the major cost is the one-time reprogramming effort to obtain a small business system-compatible pay program.

Small business systems input/output device costs, such as the on-board printer and visual display device, are the controlling cost factors, rather than cost of the processor or operating memory. Unfortunately, there are only modest reductions anticipated in the cost of visual display devices due to their current large volume of production.

In general, electromechanical devices are likely to remain roughly constant in their pricing. Thus, peripheral devices to the main processor and its associated operating memory totally control the procurement cost of the hardware for the shipboard system.

Software development costs continue to escalate, and in general, the investment in programming for major applications exceeds that of the investment in hardware. This may not be true if a relatively large portion of the Navy's larger ships were to be equipped for actual payroll computations, but still we would anticipate that the cost of converting the current COBOL payroll program to the PASCAL language for implementation on an on-board minicomputer system would cost in the range of several million dollars. An on-board system in the 1990s could well cost less than $20,000 per copy, which, if implemented for 600 ships, would give rise to a hardware cost in the range of $10,000,000.

B. MAJOR SIGNIFICANT DEVELOPMENTS

We anticipate the following major developments impacting system concepts for shipboard military pay:

1. Memory and microprocessors available such that the size and weight of storing at least 64K bytes of information and associated controls for read-out and encrypted storage could be included in a portable unit the size of a current pocket calculator or less. Thus, the concept of a machine-readable personnel record which could be carried by the individual as he moved from ship to ship, stored in a safe by the shipboard DO, and updated with a shipboard data processing system to reflect recent personnel/pay actions would be entirely feasible by the early 1990s.

2. The size of operating memory needed to store an estimated 200,000 to 300,000 instructions (maximum) required for shipboard payroll computations for individual Navy members could well be contained within a processor the size of today's minicomputer systems. Further, the cost would not be much greater than that of today's minicomputer systems with 64K bytes of memory. Thus, it would be fully feasible to do the entire payroll computation for individual Navy members aboard ship with a very small system costing less than $20,000 per ship.

3. CRT visual display devices will continue to be employed together with an electronic keyboard even into the 1990s. Costs will not reduce significantly because extremely high volume is already being achieved in both of these major subsystems.

4. While performance increases are anticipated in low and medium speed printers, because of their essential electromechanical nature little in the way of significant cost reductions is anticipated over the next decade. The major improvement anticipated is in devices capable of acting as both facsimile receivers and as output printers for alphanumeric information. These Laser xerographic printers will also be capable of acting as the printing portion of copying equipment.

Also, a facsimile transceiver of the early 1990s will be fully capable of accepting either compressed digital-facsimile image information for high quality printout, or alphanumeric information received in the form of data communications, which it can format fully to act as a normal line/page computer output printer.

5. It appears certain that by the early 1990s, there will be commercial satellite facilities available for both voice analog channels and for digital data transmission in most, if not all, areas of the world's oceans and land masses. Thus, the use and dependence upon commercial satellite communication facilities for data communications to and from Navy ships will be a realistic alternative, separate and apart from the normal military operation of satellite facilities used shipboard.

6. The integration of formatted data fields and text editing capabilities in word processor/data terminals could be used for the military pay function aboard ship as well as for personnel records and the preparation of administrative messages.

7. The ability to economically implement digital compression on facsimile images, and the ability to control the basic scanning format to achieve higher scanning speed makes the facsimile alternative for the transmission of transaction information from ships to shore facilities technically and economically feasible. This becomes even more attractive with centralized character recognition (by computer) directly on the digitized facsimile image, eliminating paper handling and paper flow in the system.

8. The ability to store the entire MPR for an individual in a thin pocket calculator/thick credit card-sized device with access controls, etc., provides a unique ability to serve shipboard Navy members well.

C. ABILITY OF ALTERNATIVE SYSTEM CONCEPTS TO DEAL WITH WARTIME CONDITIONS

One criterion which we have been asked to evaluate as a part of this study as a result of the ONR review of the preliminary report, is that of the ability of the alternative system approaches to provide continued pay service to members under wartime conditions, both limited theater and nuclear.

From an advanced pay system viewpoint, the difference between these two wartime situations is primarily that of the duration of time satellite communications would be unavailable or the time during which the ship would need to maintain radio silence. Since one objective is to eliminate the use of the U.S. Postal Service, most of the suggested alternatives anticipate the use of satellite communications from regional or international commercial satellite facilities. Based on discussions with a variety of Washington-area experts in the telecommunications field, it is generally agreed that during a limited, conventional war there is little probability that either of the opponents would desire to destroy the regional or international satellite facility. In the case of a nuclear war, a number of experts have indicated that at least the international satellites are likely to be left operational, in order to permit surrender negotiations to be conducted or coordination between surviving forces in different parts of the world. Other experts feel that satellite communications after an initial nuclear exchange are likely to be unavailable for a period of one to three months prior to the ability to launch new or additional communications satellites. Thus, the maximum time duration during which we assume there is no ability to communicate between ships and NAVFINCEN or an alternative site would be roughly three months.

In the case of a limited conventional war or radio silence during a nuclear war, we cannot visualize surface ships remaining under radio silence for more than several weeks at a time (excluding submarines).

Since essentially all of our alternatives continue to use the LES with a forecast for at least the next pay period, if not the next two pay periods, a time span of several weeks of radio silence should not have any significant effect upon any of the system alternatives evaluated.

In the case of nuclear war, where satellite facilities may be unavailable for several months and/or where the continued existence of NAVFINCEN may not be assumable, four possible approaches may be used for pay computation to serve Navy members aboard ship directly:

1. Continue to pay the same amount as the last pay period, with manual adjustments for any promotions or major changes of status.

2. Pay the same as the average of the last two to three pay periods, or those reflected in the LES for three pay periods, again with manually-entered adjustments.

All of the proposed concepts, except concepts 1 and 4, should be capable of providing the computations for either of the above implementation approaches.

3. Include a skeletal pay software program aboard the shipboard intelligent terminal/small business system. When necessary, the pay can be computed locally with an algorithm known to the central NAVFINCEN facility. After communications are restored, any exceptions between the pay made under the skeletal pay program and that due can be computed by the central facility after receiving the transactions from the shipboard computer. Transactions may need to be accumulated for several months prior to their transmission. This implies that the floppy disk storage medium may be the most desirable for shipboard use, because when one disk is filled another disk may be inserted to store additional transaction information. The full disks can then be retained until communication capabilities are stored.

4. Include a complete computational facility shipboard for military pay computations, including the estimated 200,000 to 300,000 instructions and tables necessary for the performance of these calculations. When the NAVFINCEN computer finds it does not have transmission facilities available to the ship at pay time, it can

automatically issue the necessary allotments and assume that the shipboard computer has made the correct payroll computation to give the member his pay.

The difficulty of this approach is that keeping current with Congressional, Department of Defense, and service regulations for the details of military pay would require fairly frequent updating of the complete payroll program and require a substantial amount of storage aboard for the payroll program itself in main memory.

System Concept A: CRT-Based Local Transaction Recording Device

This concept still depends on the U.S. Postal Service and requires either air pickup or docking the ship for mail drop. In a limited war situation where radio silence must be maintained, docking would not be feasible and with modern radar techniques, the use of even low flying aircraft for mail pickup and delivery may not be feasible.

In the case of nuclear war, this system concept would rely on paying members either what they had been paid the last pay period or for the past several pay periods, once the time frame of the LES received last had expired.

System Concept B: CRT Visual Display Terminal

In a limited theater of war, this system would accumulate transactions for transmission when radio silence could be broken. It is doubtful that the period of isolation would run beyond the period covered by the latest LES.

For the case of nuclear war, until communications capabilities could be re-established, members would have to be paid by some algorithm based on the amount of their last pay or some averaging of the past few pay periods as represented on their LES. However, an intelligent display terminal could implement a skeletal pay calculation, which would allow local calculation of pay with an exchangeable memory module.

System Concept C: CRT Terminal Plus Cash Dispensing and Ships' Stores' Transactions Automation

In a limited engagement, the ship would be somewhat more flexible through the effective reuse of cash and the higher availability of all personnel made possible by the automated cash dispensing and ships' stores' automated terminal equipment. In a nuclear war, the system would be particularly valuable in that it would allow Navy members to continue to charge at ships' stores and/or to obtain additional cash even though the amount of cash available aboard ship was extremely low, since we assume that a large fraction of the members would accumulate their pay in their accounts rather than requesting cash.

System Concept D: Use of Digital Facsimile Transmission

In the limited war situation, this system would provide no better pay automation than the existing approach, nor of that of the first or second system alternatives. However, it does allow the basic transaction documents to physically be sent by courier or the U.S. Postal Service if radio silence must be maintained for a longer period of time and some form of external mail facilities are provided.

In the case of nuclear war, no capability is provided for local computation other than utilizing the last pay amount or some average of the past few pay amounts as available to the DO from the LES.

System Concept E: Full Shipboard Pay Computation

Here, under any wartime or alert condition, the ship can pay its personnel accurately and on a timely basis, through purely local computer procedures and MPR file maintenance. If no satellite transmission facilities are available for reporting pay transactions to NAVFINCEN, essentially duplicate records at NAVFINCEN allow reasonable estimates of expenditures. Alternately, even mail reporting of pay actions and transactions is feasible to allow centralized MPR accounting.

System Concept F: Use of a Portable Electronic Pay Record

In the limited war situation, the correct pay amount can be developed locally, possibly using a skeletal program when communication facilities are not available.

Similarly, in nuclear war, in this concept we would anticipate that pay would be computed locally with a skeletal payroll program, and the amounts paid would be recorded in the pay record of the individual.

Adjustments would be made after communications were resumed to reflect variations between this skeletal payroll program, and the full pay calculation as done at NAVFINCEN.

SUMMARY

Essentially all of these proposed system concepts fail to provide both full MPA accountability and forecasting capability during extended limited war and nuclear war, with System Concept F providing the most comprehensive and flexible proposal. However, all but the first and fourth alternative concepts provide some form of automated support to local computation of the pay amount, utilizing various simplified algorithms ranging from simply paying the same amount as the last pay period, the average amount of the last three pay periods, or an amount calculated from a skeletal payroll program common to all ships.

D. IMPACT OF ALTERNATE METHODS

The continued reduction in the size and cost of electronic memory makes feasible the portable electronic pay record and the storage of member MPRs on a totally decentralized basis without major cost disadvantages. Thus, the technology of the 1990s will permit the Navy member to go back to the concept of the portable pay record and to the concept of having his pay computations done on a local basis where the greatest amount of control, accuracy and timeliness can be achieved. We believe that either System Concept E or Concept F will provide a much increased degree of member satisfaction with the Navy pay system and that the initial high capital cost of these systems would not be a major detriment. In fact, we believe that these costs will be more than offset by the savings made in eliminating pay discrepancies and the added security of having the MPR not only at NAVFINCEN but also aboard ship provides additional security under wartime conditions and natural disaster conditions and hence provides substantial conceptual benefit in assuring continuity of military pay functions, even if the ship itself is lost due to military action, or if NAVFINCEN were to be destroyed by natural or enemy action.

One of the major impacts of all but System Concept A is the elimination of the flow of paper from shipboard facilities to NAVFINCEN. The elimination of paper will reduce the cost of U.S. Postal Service will eliminate the need for OCR equipment and the associated operator personnel at NAVFINCEN, and will increase the accuracy and timeliness of military pay computations immeasurably. We believe the elimination of dependency upon the U.S. Postal Service for transaction flow is the essence of an improved military pay system for shipboard personnel.

XIX

NAVY RETIRED PAY SYSTEMS

Present retired Navy personnel constituting approximately 333,000 retired members and annuitants is the second largest group for which NAVFINCEN must produce a payroll. Even though this group is not a major emphasis of this survey, the following sections provide an overview of the manner in which the Navy Retired pay may be affected by the proposed system concepts.

Upon retiring, the individual member no longer has a DO or commanding officer to intercede on his behalf. His sole point of contact is the NAVFINCEN. A retiree's pay is affected by 37 different retirement laws which are or have been in effect and numerous governmental agencies such as the Veteran's Administration, Civil Service, Internal Revenue Service, etc.

Under the Navy Retired pay system, all retirees and annuitants are paid directly from NAVFINCEN. The paychecks are issued from Cleveland at the end of each month. In addition, those allotments the retired member elects to maintain are also issued from Cleveland.

A. CURRENT STATUS

Although the Navy Retired pay system has far fewer transactions per member than the active duty pay system, it is a paper-bound system which is labor-intensive and slow. It utilizes an ADP system that was designed in the 1960s. Compounding these problems is the constant growth in the number of retirees and annuitants, as well as frequent legislative changes affecting retired pay.

1. Current Procedures

When a Navy member retires or is transferred to the Reserve Fleet, a case jacket is established for him when the first source document arrives at NAVFINCEN. Upon receipt of retirement orders and statement of service from the NMPC and the JUMPS MMPA printout, an adjudication clerk determines the retiree's pay entitlements and enters the appropriate data. This adjudicator then prepares letters,

when necessary, requesting additional data from NMPC, VA, and the member. All correspondence concerning each member is maintained in the case jacket for that member. Copies of these documents are retained on microfilm as protection against loss but the original document is used as the working paper.

The Retired Pay Department of NAVFINCEN administers the Navy-wide system for the establishment, maintenance and payment of the Navy Retired and the Fleet Reserve Accounts, as well as the annuity accounts for the retiree's designated survivors. This Department currently has a staff of about 172 people who are separated into five operating divisions. These divisions are Adjudication, Casualty and Annuity, Technical, Systems, and Records. The Adjudication Division establishes all the new retired pay accounts; it investigates claims, adjudicates and processes documents, claims and payments and initiates computer input actions. The Casualty Division processes deceased cases and claims, establishes and closes out survivor benefit annuities. The Records Division establishes and maintains Retired pay case jacket files and submits all Retired pay computer input to the operations division of the data processing department. The Technical Division analyzes, evaluates and interprets laws, judicial decisions and administrative rulings pertinent to Retired and Fleet reserve payments. The Systems Division analyzes and monitors all ADP systems utilized by the Retired Pay Department. It develops requirements to implement systems modifications and improvements and assists data processing and retired military pay specialists in effecting legislative adjustments to the Retired pay system and MPAs.

The Retired pay account for an individual member consists of two parts: the Retired Pay Master Account (RPMA) on magnetic tape and individual retirees' pay jackets. The RPMA contains all the necessary member identification data, such as retirement date, entitlement and pay computation codes, years of services, disability status and VA claim number (if applicable), allotment and tax data, and dependency information. Additionally two addresses may be maintained on the master file for each member: a check mailing address for EFT and a correspondence address for those members who do not reside at the address to which their monthly net pay is sent. This file also contains monetary summaries for taxable income, withholding tax, and survivor benefit costs which are used for year-end reports.

The bulk of NAVFINCEN work effort either initiates with or culminates in mail. Therefore, the speed and control of mail handling is critical to the Center's functions. All mail involving adjudication of a retiree's pay is separated and assigned routing codes for control. Beneficiary case jackets are removed from the files and attached to the incoming mail which together are entered as a backlog item in the Automated Case Control System and maintained there until the required changes are completed. Due to the complexities of laws and regulations governing Retired pay and annuities, many transactions are time dependent. They require NAVFINCEN action after a specified passage of time or on a particular date different for each individual. The current automated Retired pay system provides limited tickler service, and the annuity service tickler file is a box of 3 x 5 cards. These time-dependent actions, as well as telephonic requests, are handled the same way as correspondence based actions in routing a member's jacket into the backlog files.

2. Current Deficiencies

Although the current number of transactions in each retiree's account is considerably less than the average number of transactions in active duty and reserve accounts, the basically manual procedures used in handling the retired accounts creates a significant backlog in unresolved actions. In addition, because of the relatively few transactions to the retired accounts, error correction is extremely slow. The current RPMA has a limited number of data items. The annuity card system is even more limited. If a report is required which cannot be constructed from this limited data, it must be compiled manually. The Retired Pay Department is faced with an ever-growing problem of keeping track of the multitude of correspondence, transactions and rejects flowing through the total system. If transaction tracking could be made a part of a total on-line ADP system rather than a separate stand-alone system, the usefulness and integrity of the data would be improved.

The Retired pay program suffers certain deficiencies in security. Security for this system encompasses three different aspects: (1) physical security of Retired pay files from sabotage, attack, or natural disaster; (2) security of retiree's personal information from theft; and (3) security from fraud. The current system depends heavily on the paper Retired pay files which have no

comprehensive backup. Because they are essential to day-to-day operations, the paper files are located in the A.J. Celebrezze Federal Office Building in downtown Cleveland. Although the files are in a restricted area, the building in general is open to the public. It is most difficult to prevent unauthorized intrusion. Microfilm files are now being phased in as a cost-effective means of creating backup files, which will provide the additional advantages of reduced storage space, reduced transportation costs and improved retrieval capabilities. There appears to be adequate security in the aspect of preventing theft of personal information from the files. However, there is no security from fraud except for administrative spot check reviews by supervisors, peer reviews, control of blank checks and random investigations by internal auditors every few years. There are no good preventative measures established to ensure that the administrative examiner or internal auditors check for fraud. In general, the procedures of the Retired pay system tend to be targetted toward ensuring accuracy rather than preventing fraud.

In summary, the current system provides a low level of control and limits the ability of a manager to assess problems or potential problems, to receive accurate and timely financial information, and to react to various processing necessities.

B. OBJECTIVES FOR IMPROVEMENTS

The stated objectives for improving the Retired pay system are as follows:

- Improve responsiveness to required transactions
- Improve accuracy of the adjudication matters
- Increase the efficiency of the transactions
- Increase the use of new technology
- Improve the security of the Retired pay accounts
- Increase the number of retired members using EFT

In approaching the above objectives, the Navy is in the process of converting the Retired master pay files to disks, with about two-thirds of the files already converted. With this conversion and the subsequent ability of random access, much greater control of the retired pay accounts is expected. This conversion to disk storage will contribute to most of the foregoing objectives, in varying degrees.

1. Responsiveness

It is expected that the time required to take action and to respond to an inquiry or request for change will be reduced to an average of ten days. New accounts will be established within the 30-day time requirement with an accuracy of about 90%. The establishment of an annuitant and the payment of arrearages of pay is expected to be reduced from the present five days to the date of the claim's receipt. This will provide a capability to retrieve information concerning a member's account within an average of five minutes, and reduce the maximum time for system response to input actions from eight days to twenty-four hours.

2. Accuracy

Manual calculations are expected to be reduced by 90% and the Retired Pay/Annuity Master Files are expected to be current to within 24 hours.

3. Efficiency

Transferring the Retired master files to disk storage will be a big step toward the objective of reducing the maintenance cost of each retired member by 50% and each annuity account by 10%. The efficiency will be further improved when the current fie'd paper input media is substituted with machine-readable media.

4. Technology

Disk storage of the basic records will enhance the future capability of using standard computation routines so as to produce not only the paycheck but the desired periodic management reports. Further steps are being made to standardize data elements to provide interface with other systems within NAVFINCEN.

5. Security

Disk storage will enable the Retired Pay Department to eliminate its dependency on the hard copy Retired pay files contained in the members' jackets. It also will permit random unscheduled drawoffs of account data, greatly enhancing the audit capability of the program.

6. Increased Use of EFT

In its conversion to EFT transmission of retired paychecks, the Navy did not use the intermediate of Composite Pay as the other military branches did. Each retired Navy member must fill out the U.S. Treasury Form No. 1199 and present it at his bank or other financial institution. Although the Navy is encouraging its retired members to use EFT, the conversion process is relatively slow because of the necessary action by each individual member.

C. EFFECTS OF PROPOSED SYSTEM CONCEPTS

The proposed system concepts would affect the Retired pay program significantly less than the active duty or reserve pay programs. This is due to the fact that all of the data and transactions to retired pay accounts, once each account has been established, are handled at NAVFINCEN in Cleveland, rather than shipboard.

1. System Concept A

The major improvement to the Retired pay program of this system concept would be the reduction of machine readable data from NMPC and the field to speed the establishment and accuracy of the new retired accounts. Adjustments and changes in the individual's accounts would be entered directly into the present disk storage at NAVFINCEN by the account managers through one of the CRT devices installed at NAVFINCEN. The insertion of the changes in the member's record would not be recorded on a removable disk media, such as a floppy disk, but would be inserted directly into the permanent disk storage in Cleveland.

2. System Concept B

Since the CRT terminals used to update the Retired pay accounts are installed at NAVFINCEN in Cleveland, all changes to the accounts would be automatically on an on-line basis. The primary advantage of this system concept would be in the initiation of a retiree's account in that the initiating orders would be transmitted electronically from NMPC.

3. System Concept C

This concept is concentrated primarily on the shipboard transactions of the active duty members. Since the retired members receive their pay directly from Cleveland, either via the U.S. Postal Service or EFT, minicomputer capability and personal identification cards would be of no benefit to the retired members.

4. System Concept D

The use of a facsimile transceiver would speed up the establishment of new retiree accounts. Under this concept, once the retired payee account is established, all transactions would be made in Cleveland, probably via the CRTs now being installed there.

5. System Concepts E and F

The use of a portable electronic pay record would be of little advantage in the Navy Retired pay system. A pocket-sized electronic payroll record issued by the Navy would be of use to the individual members only when a personal visit is required to resolve problems their pay accounts. The machine-readable service record would ensure rapid entitlement resolution.

D. SUMMARY

The major requirements for upgrading the Navy military pay system is the improvement of data entry and the processing of information. In the retired pay program, tranmission of the originating documentation via electronic means and/or in machine readable form can be expected to increase the accuracy and speed of the establishment of the retired accounts. The conversion of the basic data in the retired accounts to disk storage in Cleveland, coupled with the ability to access this information via the CRT installations there, can be expected to greatly improve the service provided to retired members and their survivors. Greater use of EFT for paychecks is being pressed by the Navy with the resultant savings in mailing and printing costs. Since the decision to use EFT transfers is individual, a complete conversion to this type of transmission cannot be expected soon.

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NAVY RESERVE PAY SYSTEMS

Among the several groups for which NAVFINCEN must produce a payroll, the Navy Reserve is included. Although this group is not within the major emphasis area of this research, we provide in the following sections an overview of the manner in which these systems may be affected by the alternative system concepts for active duty pay.

NAVFINCEN administers five pay systems for the reserve component of the Navy. These are:

- Naval Reserve Drill Pay (NRDP)
- Servicemen's Group Life Insurance System (SGLI)
- Naval Reserve Officer Training Corps (NROTC)
- Armed Forces Health Professions Scholarship Program (AFHPSP)
- Active Duty for Training (ACDUTRA)

As a part of the automated data system development plan of MPSIP, there is a proposal to upgrade the components of these pay systems to assist NAVFINCEN in administering this responsibility. The evaluation of the Navy Reserve pay systems are related to this proposed plan.

A. CURRENT STATUS

Although the Naval Reserve pay system has fewer accounts than the active duty pay system, it includes five separate systems of transactions and payments. Additionally, the reserve system requires a large number of manually inserted transactions; thus the system generates many of its own problems. The majority of the reserve payments are made directly from NAVFINCEN.

1. Current System

NRDP provides monthly payment to some 80,000 reservists. A recent innovation is the Reserve Field Reporting System--known as "RESFIRST"--which uses OCR documents to report drill performance. Data flows from the individual reservist who initiates a drill "chit" at the reserve unit to the Naval Reserve Personnel Center in New Orleans. There are roughly 200 Naval reserve units throughout the country.

The chit is recorded on magnetic tape at the New Orleans center and forwarded to NAVFINCEN via NMPC. The pay is computed at the finance center and mailed to the reservist by check on the 20th of each month.

There are no specific details available on the other systems utilized for Naval reserve pay. The overall number of transactions are minor in comparison to the active military pay and retired--amounting to some 86,000 members in total.

2. Current Deficiencies

Presently, the reserve pay system is composed of five stand-alone systems and is only partially automated. NAVFINCEN administers the five spearate pay systems. The Naval Reserve Department coordinates the NRDP. Payments are effected for drill pay, command pay, incentive pay, officers' uniform allowances, enlisted clothing monetary allowances and related payments in the case of NRDP. The ACDUTRA claims are also paid by the Naval Reserve Department. Much of the transaction information must pass through the personnel group and then be forwarded to the Center for payment.

The result of the utilization of five separate systems and the forwarding of information through New Orleans to Personnel to the Finance Center provides considerable opportunities for problems to develop and unacceptable time delays. Further, the payment of the ACDUTRA members from the active duty stations tends to add complications rather than simplify the system.

Thus, these systems with no ability to interface with each other, as well as the overall lack of centralization have produced a system which is inefficient and is not cost effective. As a result, the plan for improving the two major components of the reserve system, NRDP and ACDUTRA, and integrating the other systems into the overall plan should provide better service and cost benefits. Since the overall major deficiencies of these systems are identical to the other portion of the military pay systems, improvements can be made in the active duty system which will benefit the reservists also.

B. OBJECTIVES FOR IMPROVEMENTS

The overall objectives of improving the Reserve pay systems are as follows:

- State-of-the-art capabilities for reserve system processing
- Speed of data entry into the five reserve systems
- Internal control of the four data bases
- Combination of the data bases
- Reject control and correction
- Management information and financial reporting capabilities
- Standardized data elements for automated interface with active and retired pay systems
- EFT for reserve members

1. Current Plan for Improvement

There are three separate revisions planned for the five reserve systems. The first increment is to redesign the NRDP system in order to standardize data elements and to upgrade the system with current state-of-the-art processing. The improvements must also meet PASS transmission schedules.

The second increment is to provide the Reserve pay system with further refinements which include integration of the rserve pay systems, establishment of on-line inquiry capability, an automated input system, the improvement of financial reports, the establishment of a management information system, a reject control system and an automated data transfer system with other in-house pay systems.

The third increment is the centralization of the ACDUTRA portion of the system. The purpose of centralizing ACDUTRA is so that the member's checks for earned basic pay and allowances will be issued from NAVFINCEN rather than from the active duty stations.

2. Expected Benefits

There are a variety of expected benefits to be reaped from planned improvements in the Reserve pay system. These can be itemized as follows:

- Decrease the average clerk time involved in the correction of a NRDP account by 20%
- Reduce the average time involved in answering customer service telephone calls for all reserve systems by five minutes per call
- Reduce the average time involved in working claims by 5%
- Reduce NAVFINCEN edit processing errors by 10%
- Provide management with detailed information on system processing, drill totals, and personnel data for the NRDP, and similar information for the other four systems involved
- Reduce the NAVFINCEN Reserve Pay Department operating costs by 23%
- Eliminate the keypunching support for the Reserve Pay Department
- Reduce the amount of filing time in the Reserve Pay Department by 20%

The centralized ACDUTRA will produce the following benefits:

- Provide an audit trail of ACDUTRA performances for both in-house and field use
- Post ACDUTRA dates and pay and allowance data to the NRDP master without manual intervenion
- Centralize field computation of ACDUTRA pay and allowance
- Issue a check to 95% of all active duty for training reservists by the completion of their ACDUTRA period and to issue the remaining 5% within seven days of completion of the duty period

- Provide earnings statements to all reservists performing ACDUTRA
- Provide all reservists with one W-2 form from the central site by 30 January of the following year
- Account for all reserve obligations and expenditures from NAVFINCEN
- Report obligations to CNAVRES, expenditures to the Centralized Expenditure and Reporting System, Federal and state income tax withholding, if necessary, to the appropriate taxing authorities on all reserve ACDUTRA pay
- Include ACDUTRA data management information system reports as required by CNAVRES
- Pay all ACDUTRA claims through NAVFINCEN
- Develop an ACDUTRA system compatible with the PASS environment
- Provide management information reports needed by the Reserve Pay Department to control ACDUTRA payments
- Eliminate duplicate payment for drill pay and ACDUTRA

C. RELATIONSHIP TO PROPOSED SYSTEM CONCEPTS

The closer integration of the Reserve pay system into the overall active duty and retired pay systems is a major objective of the planned improvement of this program. In the following sections, we briefly outline the opportunities for integrating the Navy reserve pay requirements into the alternate system concepts developed in this research project.

1. System Concept A

The major improvement proposed by this system concept is the ability to locally record and edit information in machine-language for mail transmission to the central facility for processing. In the current system for reserve pay, this would imply that a CRT data recorder could be located at the New Orleans center. Ideally, a data recorder at each of the reserve units could reduce the input of errors even further. Local memory would also provide a reference for the input of information to reduce error production. Disks could be forwarded weekly to New Orleans from transmission at Cleveland.

2. System Concept B

System B adds the further refinement of having an intelligent data terminal operate in an on-line mode directly to the Center. Since the major portion of the reserve units are shore based, the terminals could be connected to the host processing centers anticipated under PASS II.

Since this system concept provides for on-line connection, it most closely meets the objectives of the proposed system improvements. Additionally, all five systems could be operated in this way.

3. System Concept C

Most of the accoutrements of this system concept are related to shipboard requirements. The major benefit for the Reserve pay system would be the on-line storage for all transactions and the skeletal military pay record. This would enhance the handling of the reservists' payments and provide the necessary

checks and balances in the system to prevent over or underpayments. The requirement for minicomputer support, however, may be a little in excess of the requirements of the Reserve pay system. The use of an identification card could prove beneficial when reserve members go on active duty.

4. System Concept D

This system calls for the transmission of documentation directly to the finance center via facsimile. It may provide the benefit of reducing some of the errors which are generated by the system and it would certainly speed up the transmission of information. The systems could all possibly be integrated with one another in a much simpler manner, but this is questionable since many of the details are unknown to us.

5. System Concepts E and F

The use of a portable electronic pay record may be overkill for the Reserve pay system. Since reserve members do not participate on a daily basis, it would be easier to provide a terminal or input device at the local reserve unit and not have to accommodate 80,000+ members with a payroll record. Further, since many will forget the cards from time to time for reserve drill which lasts such a short period of time, a replacement (even temporarily) would not make much sense. As a result, this system concept does not have a major contribution to make to the problems involved in this pay system.

Summary

The major requirement for upgrading the Reserve pay system is the improvement of data entry and rapid transfer of information. The integration and automation of the several systems is another major area requiring attention. Further, much of the improvement could take place at NAVFINCEN and at the local reserve unit. Thus, the system can be centralized and integrated with a terminal used by all facets of the system. The use of EFT for payment could reduce the costs of transmitting pay throughout the country and effect a cost savings that would be attractive to NAVFINCEN as well as provide better serv to the reservist.

XXI

FINANCIAL REPORTS AND FISCAL CONTROLS

The Chief of Naval Personnel (CHNAVPERS) is responsible for budgeting and accounting for the MPN appropriation to Congress directly and through GAO. To meet this responsibility the Chief must rely on the financial reports produced by NAVFINCEN from the MPAs maintained for the Navy members (active duty, reserve and retired).

A. INACCURATE BUDGET REPORTS

Based on the payroll data provided by NAVFINCEN, the appropriations manager of the MPN prepares the manpower budget, which is included in the total military budget presented to Congress for the succeeding year's appropriation. Once the appropriation has been approved, the MPN's appropriations manager reconciles the actual manpower expenditures, including accruals of unpaid obligations, to the budgeted amounts.

The current financial reports produced by JUMPS are monthly reports limited to a fixed structure and not sufficiently flexible to support the MPN appropriations manager's requirements without excessive manual manipulation and adjustment. Certain data included in the financial reports is needed by the MPN appropriations manager in a different sequence to meet the budget requirements. Therefore, the monthly reports must be manually reconstructed to meet the budget needs. Even with all this manual effort, the Navy is still criticized by the GAO and the Navy Audit Service as well as the Congress for late and/or inaccurate budget reports.

B. OBJECTIVES FOR IMPROVEMENT

One ultimate objective of the Navy to improve the accuracy and timeliness of its budget reports is to provide the MPN appropriations manager on-line access to the MPR files stored in Cleveland. This will assure the availability of current financial data to the appropriations manager within 24 hours of MPA update at NAVFINCEN, thus allowing timely responses to inquiries from higher authorities.

It is obvious that the format and content of some of the financial reports must be altered to provide the quick response required by the appropriations manager. Our study assignments covers only alternative and improved means of transmission of the basic data into and out of NAVFINCEN. In the following sections, we briefly outline the effects the proposed system concepts might have in improving the transmission of the necessary data into NAVFINCEN.

1. System Concept A

This concept would improve the capabilities of the appropriations manager in the budgetary process only marginally. The substitution of machine-readable floppy disks for OCR paper documents would speed up the overall transfer of data to the members' MPRs. But since it remains based on the U.S. Postal Service, significant and unacceptable delays would continue.

2. System Concept B

It must be assumed that under this concept the MPN appropriations manager would also have access to a CRT device and be a part of the Navy electronic transmission network. Through the use of an intelligent CRT terminal, and the electronic transmission network, the MPN appropriations manager will be able to produce the budget reports in whatever format is desired or needed. This concept will also permit timely and accurate answers to questions and requests for additional information from Congress and others in authority.

3. System Concept C

Since this concept retains the intelligent CRT terminal and electronic transmission provisions of Concept B, it will provide the same advantages to the MPN appropriations manager. The shipboard minicomputers might provide the appropriations manager with additional controls on cash accounting and requirements in that they could be preprogrammed to provide summaries of cash transactions in whatever format the appropriations manager required.

4. System Concept D

The primary advantage of this concept to the MPN appropriations manager would be the substitution of electronic transmission of data for the U.S. Postal Service. The elimination of the paper image of the facsimile document coupled with the on-line edit capability would ensure that the MPRs would have the desired accuracy required by the appropriations manager. However, the use of facsimile documents would require that the appropriations manager predesign reporting forms to provide the necessary budget information and that appropriate facsimile equipment be installed in the offices of the appropriations manager.

5. System Concepts E and F

The individual electronic pay record would not materially aid the MPN appropriations manager. The electronic transmission of data to NAVFINCEN included in this concept would be of signficant value in the production of accurate and timely budget reports.

The shipboard pay computation and check preparation envisioned by both of these system concepts reduces only slightly the appropriations manager's information availability, since actual pay made is reported to NAVFINCEN each payday (or within one day thereafter). Only when the ship must maintain radio silence or cannot communicate, is there more than a few days' delay in accurate statistics on appropriations expenditures.

C. SUMMARY

Of the six concepts presented in this report, only Concept A would NOT materially benefit the MPN appropriations manager in the budgeting and reporting functions. In the other four concepts, the use of electronic transmission of data and the transferring of the MPRs to permanent disk storage will give the MPN appropriations manager the capability of on-line access to the JUMPS files. With this capabiity, the required reports and reconciliations can be produced with the desired accuracy and timeliness.

XXII

CONCLUSIONS AND RECOMMENDATIONS

This study effort was not oriented toward the development of recommendations, but rather to a forecast of developments, conceptual alternatives, and their comparison. Our conclusions similarly are brief.

A. CONCLUSIONS

1. Continued use of the U.S. Postal Service gives rise to intolerable delays and the resultant errors in pay records leading to gross inefficiencies in shipboard pay administrative resource use. This must be corrected soon.

2. Electronic transmission of field transactions and LES data will solve most shipboard pay problems and will permit exception reporting from the field.

3. Several valid and manageable advanced system concepts have been identified. Each offers members better service, significant reductions in shipboard pay administration viable wartime pay methodology.

4. The requirement for allotment payment check distribution makes full decentralized shipboard-level payroll computation (exclusively) impractical.

5. Current shore-based pay system improvement programs have had a great impact on shipboard pay procedural possibilities, since random access and under most of the alternatives concepts considered for shipboard pay systems, a high degree of centralization of Naval military pay records and computational support can and should continue to exist, since the proposed use of commercial satellite channels for data transmission has a usage-related cost insensitive to distance.

B. RECOMMENDATIONS

A few recommendations are in order:

1. Obtain independence from the U.S. Postal Service by installing commercial satellite data terminals aboard ship as soon as possible. Use commercial satellite data services to eliminate paper flow.

2. Install some form of transaction capture and electronic transmission facility aboard ship, either CRT data terminals or facsimile.

3. Initiate further research effort to study the personnel transaction aspects of shipboard personnel management and the integration of data base information for either shipboard and shore-based file storage and the joint use of reported transactions for personnel and pay purposes. This effort should also examine the joint use of CRT data terminals and of a commercial satellite earth station terminal aboard ship.

4. A further, more detailed, study of the costs and benefits associated with the portable electronic pay record should be initiated.

APPENDIX A
LIST OF ACRONYMS

LIST OF ACRONYMS

ACDUTRA	Active Duty for Training
ASCII	American Standard Code (7 bits + parity)
AUTODIN	Automated Digital Network
BUPERS	Bureau of Personnel
CCD	Charged Couple Device
CCITT	Consultive Committee International Telephone and Telegraph
CMOS	Complementary Metal-Oxide Semiconductor
CNAVRES	Chief, Naval Reserve
COMNAVTELCOM	Commander of Naval Telecommunications
CPU	Central Processing Unit
CRT	Cathode Ray Tube
DK	Pay Clerk
DO	Disbursing Officer
EAROM	Electrically Alterable Read Only Memory
ECCO	On-LIne Error Correction and Control
FMIP	Financial Management Improvement Program
ICR	Image Character Reader
JUMPS	Joint Uniform Military Pay System
LES	Leave and Earnings Statement
LSI	Large Scale Integrated circuit
MAPMIS	Manpower Personnel Management Information System
MMPA	Master Military Pay Account
MPA	Military Pay Account
MPF	Master Pay File
MPN	Military Personnel, Navy
MPR	Master Pay Record
MPSIP	Military Pay System Improvements Plan
MTBF	Mean Time Between Failures
NAFC	Navy Finance and Accounting Center
NARDAC	Naval Regional Data Automation Command
NAVFINCEN	Navy Finance Center

NMPC	Navy Military Personnel Command
NRDP	Navy Reserve Drill Pay
OCR	Optical Character Reader
OEM	Original Equipment Manufacturer
PFR	Personal Financial Record
PMF	Pay Master File
PN	Personnelman
PPS	Payday Processing System
PROM	Programmable Read Only Memory
PSA	Personnel Support Activity
PSD	Personnel Support Department
RAM	Random Access Memory
ROM	Read Only Memory
RPMA	Retired Pay Master Account
SJUMPS	Shipboard JUMPS
SPC	Stored Program Control
TDMA	Time Division Multiple Access
UIC	Unit Identification Code
UART	Universal Asynchronous Receiver/Transmitter
VLSI	Very Large Scale Integrated Circuit

APPENDIX B
TRANSACTION STATISTICS

Transaction Statistics

Navy Personnel:	
Active Duty	525,000
Reserve	86,000
Retired	322,000
TOTAL	933,000

Navy-wide Volume of Transactions (Monthly Average)

Field Level Transactions	
Pay Entitlement Transactions	800,000
Payment Transactions	1,050,000
Allotment Transactions	190,000
Family Separation Transactions	156,000
Reserve to Active Duty	67,000
Leave Transactions	75,400
Report Detachment	24,500
Report Attachment	24,500
Reenlistment Bonus	2,100
Grade Change-Enlisted (NMPC)	13,000
Disciplinary Actions (NMPC)	4,000
TOTAL INTO NAVFINCEN	2,205,500
Daily Diary Transactions into NMPC	120,000
Generated by NAVFINCEN	
LESs	611,000
Reserve Paychecks	86,000
Retired Paychecks	231,000
Retired Pay-EFT	91,000
Allotment Payments	290,000
TOTAL OUT OF NAVFINCEN	1,309,000

APPENDIX C
FORMS USED FOR NAVY JUMPS

A. Navy OCR Forms for Payroll Transactions

Form No.		Title
1.	3051	Transmittal Letter Included with and identifies each transmission.
2.	3052	Employees (Members) Withholding Exemption Listing Initiation and changes only.
3.	3053	Allotment Authorization (Start, Change & Stop Allotments) One form for each member.
4.	3055	Military Pay Voucher For individual payment or as coversheet for Form 3056
5.	3056	Military Payroll Money List (Form always accompanied by Form 3055) Amount of pay due each member. Each form up to 24 members.
6.	3056T	Military Payroll Money List Members receiving cash payments must sign.
7.	3057	Family Separation Allowance For individual member or as coversheet for Form 3058.
8.	3058	Family Separation Allowance (Multiple) Must always be accompanied by Form 3057.
9.	3060	Military Pay Order Used for changes in individuals pay. Form will hold up to 7 individual changes.
10.	3061	Military Pay Order (Multiple) Used when several members receive some pay change for one common reason.
11.	3062	Orders for Hazardous or Special Duty Used when one or more members are ordered to perform hazardous or special duty or when such duties are terminated, suspended or reinstated.
12.	3063	Overseas Station Allowance One form per member. Covers cost of living allowance, housing allowance, interim housing allowance, and temporary lodging allowance.

13.	3064	Basic Allowance for Subsistence Used to report number and kinds of meals missed from a government mess. Officers and enlisted cannot be combined on one form.
14.	3065	Leave Authorization (Officer & Enlisted) Used to authorize and report ordinary leave, sick leave, graduation leave and emergency leave.
15.	3065A	Leave Authorization (Officer & Enlisted) Used to report early return from leave.
16.	3065 R1	Leave Authorization Used to report when leave authorization is changed prior to departure.
17.	3065 AR1	Leave Authorization Used to report extension of leave.
18.	3066	Uniform Allowance Claim Used to support uniform allowance entitlement.
19.	3067	Detaching (Departing) Endorsement to Orders Used when member is separated, detached on PCS orders, detached from a TDY point, detached from permanent duty station on TAD, detached from any TAD point, or transferred from one UIC to another.
20.	3068	Reporting (Arrival) Endorsement to Orders Used when member arrives at new station.
21.	3069	Detaching (Reporting) Endorsement to Orders - Group Travel Listing Officers and enlisted not combined on form. Always must be accompanied by Form 3067 or 3068.

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ADVANCED MILITARY PAY SYSTEM CONCEPTS. EVALUATION OF OPPORTUNIT--ETC(U)
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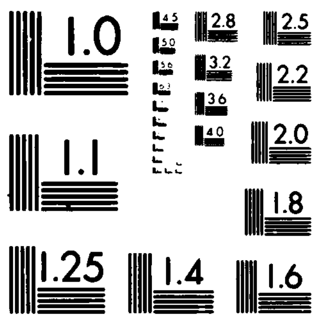

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

B. Navy Personnel OCR Forms Affecting Payroll Transactions

These documents go from field to NMPC and from there to NAVFINCEN. They are the ones that cause most of the delays.

	Form No.	Use
1.	1070/601	Immediate Reenlistment Contract
2.	1070/602	Dependency Application/Record of Emergency Data
3.	1070/621	Agreement to Extend Enlistment
4.	1070/622	Assignment and Extension of Active Duty Used when an enlisted reservist or retiree agrees to extend his tour of active duty. Also when he cancels his agreement to remain on active duty.
5.	1070/606	Record of Unauthorized Absence If the member: 1) Is UA over 24 hours. 2) Intentions to desert are manifest. 3) Is in hands of Civil Authorities (not preceded by UA). 4) Is UA and is apprehended and charged by Civil Authorities. 5) Is UA for 30 days. 6) Returns from UA and has been UA over 24 hours. 7) Returns to an activity other than activity UA from. 8) Is UA and in hands of Civil Authorities (I HCA). 9) Returns to military jurisdiction from I HCA. 10) UA is charged to Sick Misconduct (SKMC). 11) UA is excused and time charged to Leave. 12) Returns from UA to Non-Navy Military Jurisdiction. 13) Correct errors on previously submitted Form 1070/606. 14) Discharged in Absentia.
6.	1070/607	Court Memorandum 1) Sentenced to reduction of pay grade. 2) Advanced to paygrade E2 upon release from confinement. 3) Sentenced to forfeiture of pay. 4) Sentenced to a fine. 5) Sentenced for contempt of court. 6) Sentenced to a deduction of pay. 7) Found guilty of desertion - or found not guilty.

8) Released from pretrial confinement.
9) Sentenced to confinement.
10) Released from confinement.

7. 1070/610

Record of Personnel Actions

If a member:

1) Is awarded a proficiency.
2) Loses his proficiency.
3) Changes proficiency levels.
4) Advancements through competitive examinations.

APPENDIX D
PAYROLL CONCEPTS IN PRIVATE INDUSTRY

PAYROLL CONCEPTS IN PRIVATE INDUSTRY

One approach to discovering the current and future trends in payroll system technology is to look closely at the methods used in private industry in the U.S. The basic assumption with which we began our research was that companies which have a large contingency of mobile personnel are likely to provide a reasonable basis for comparison. This ultimately proved to be only marginally true. The requirements for many of these companies, in fact, were often very different. Although personnel were mobile, they were classified by a home domicile location which was almost the same as not being mobile at all.

From this point, we began to investigate in general the major corporate entities which were deemed likely to have sophisticated systems for payroll. Although these corporate entities did not share the same requirements as that of military pay, we were able to ascertain that in the majority, payroll systems appear to be similar nevertheless.

A. OVERVIEW OF CORPORATE PAYROLL SYSTEMS

The state-of-the-art of payroll systems in private industry is not very advanced. It is a corporate overhead item and not an area that commands much attention until problems or major deficiencies develop. Overall, however, most corporations do recognize the importance of accurate and up-to-date record keeping. Further, there are varying types of regulations which affect employee payroll and corporations must meet the demands of these requirements. Corporate payrolls must also accommodate varying types of employees and different wage scales--such as hourly, exempt, nonexempt, part time, etc. Of the groups interviewed, it appears that most payroll systems do have much in common.

1. Mobile Personnel

The initial interviews we conducted with companies likely to have a large contingency of mobile personnel indicated most were assigned a home domicile.

The employee's records and salary were controlled by the location to which he or she was assigned. Therefore, there was little requirement for payroll to "catch up" with this tupe of employee, since they were not frequently transferred either. In effect, these employees were usually mobile for only a short time, or in other cases were located for a specific length of time to a tour (the circus) or a job site (Bechtel). For mobile employees which are located in the field on a "permanent" basis, a local system was developed to accommodate payroll and the information submitted to corporate for record keeping purposes.

Another interesting facet of the mobile personnel associated with the transportation industry is that the company also had a built-in method for transmitting payroll information. In several cases, trunking companies used their own trucks between facilities to transfer payroll documents.

While the various methods of accomplishing payroll are of interest, there was very little in the way of comparison with the requirements of the Navy payroll system that proved of significant interest to this survey. As a result, we next called various corporations which were indicated to have a modern and automated system concept. Most of these companies were identified by the payroll managers with whom we spoke. There is an association for payroll managers in the U.S. Hence, through yearly conventions and meetings, most of these managers learn what other companies are doing in the area of payroll.

2. Centralization of Payroll

The payroll function in U.S. corporations is almost without exception performed on a centralized basis. Historically, payroll was centralized by U.S. corporations since it was felt this was a more economic approach to performing these tasks. Formerly, it had been decentralized. It seems fairly evident that industry is slowly being pressured to go back to the decentralization of payroll for at least a portion of the functions involved. What likely will change is the method for accomplishing the payment of employees while maintaining some central corporate control over payroll.

Corporate payroll systems will likely develop in that much of the initial transactions will be done on a local or regional basis and submitted to a central system. There is likely to develop a capability for local printing and distribution of payroll checks, unless EFTs become more popular. A few companies are now planning for some regionalization and modernization of payroll. The few that are will not likely develop any major change for the next three to four years.

3. Corporate Attitudes Towards Payroll

Generally speaking, industry is not prone to give payroll a very high priority. The cost of doing payroll is overhead and one which corporations wish to keep as low as possible. Many corporations have automated their payroll systems to one degree or another, however, it has been slow and primarily patch work.

There is some recognition on the part of companies we interviewed that indicated a desire to redo the payroll system from the ground up. However, most are slowly automating the systems a piece at a time. Further, much depends on the individual character of the industry and type and kind of payrolls which are required. Bus drivers are paid by the slip, others by the trip, there are hourly wages, yearly salaries, etc. This is certainly one of the controlling factors over the type of system which can best serve the needs of the corporation and its employees.

U.S. industry also has assumed more control over employees in the payroll system compared to the Navy's policies for paying members. In private industry there is little accommodation of paying up to the day or in cash. Often there is a two-week lag in payroll to allow for processing, although several states have laws which limit the lag to no more than seven days. Further, lost checks or other payroll problems are seldom resolved on the spot. Employees know they must wait until the central system makes the adjustment. Most of the companies interviewed did have a type of contingency fund or salary advance system developed to handle emergency cases only. In a nutshell, industry is much less "understanding."

4. Payroll Disbursements

In the majority of cases, payroll checks are printed at the central facility and "mailed" to the various locations of the corporation. Mail may mean a number of types of services, including Federal Express, air freight, and special delivery, as well as couriers. Some dissatisfaction with the U.S. Postal Service, which is used in the majority of cases, was expressed concerning slowness of service and lost mail. Overall most systems still rely on the postal service.

The McDonald Corporation transmits the information via computer to its headquarters in Illinois and then transmits payment information back to the regions for check printing. Marriott indicated they wished to go to a system that generates the pay checks at the regional level. Paychecks which are printed in the regional levels can be delivered faster than from a completely centralized location.

The primary medium for input from the field is also mail. Very few corporations have the automated ability to input payroll information from CRT terminals or other media on-line. Expense is the major limitation on this type of automation. Generally, the media for the collection of payroll information are time cards, punch cards, magnetic tape, etc. which are transmitted to a central location for processing.

5. Error Correction and Payroll Adjustments

Payroll in private industry is almost exclusively by check. Cash is almost never given to employees which helps avoid many problems in accounting for cash and verification procedures. Private industry can force, to a minor extent, the employee to await a payroll correction until a new check has been issued, if lost, stolen or incorrect. We believe private industry has a bit more leverage in this situation than the Navy has considered up to this point.

However, it is recognized that certain problems can occur with employees' paychecks and salaries. Thus, most organizations made some allowance for a type of contingency fund at the local level. Most often they offer an employee

a salary advance which could then be reconciled after the fact. In the case of the loss of bulk mailed checks, one company indicated that a payroll could be reissued in one day and air freighted counter-to-counter to the local area. Generally, salary adjustments or error correction by salary advance is not encouraged by private industry, although most indicated errors could be corrected in approximately one week.

In most instances, vacation time and other kinds of leave records were maintained within the local facility. The local facility and the centralized personnel/payroll facility must reconcile the employee's records with the time taken. The local facility keeps concurrent records and is able to grant vacation time to an employee. Any discrepancy with headquarters is usually reconciled after the fact.

7. <u>Use of Electronic Funds Transfer</u>

We found no organization that was using EFTs nor any that anticipated using it in the near future. This, however, does not indicate that there are no organizations using EFTs. It seems likely that many corporations have not fully considered the benefits of this service which is still very early in its introductory stages.

8. <u>Personnel Records</u>

The majority of corporations have integrated at least a portion of the personnel records with payroll. Several corporations expressed a desire to completely integrate these two functions, but generally personnel still existed as a separate department and was not integrated with payroll.

B. FUTURE TRENDS IN PAYROLL

During the course of our interviews with these corporations we inquired as to the future plans for modernizing payroll. There were only two corporations that indicated a major system redesign was in progress. Generally, most corporations hoped for some portion of the system to be modernized. In the case of at least one corporation, the modernization and complete automation of payroll had just been completed.

1. Decentralization or Regionalization

Many payroll managers mentioned the extreme difficulty in being relevant and up-to-date on the various payroll functions, due to the distances involved. The turnaround time was slow and in general, corporate headquarters and payroll were far removed from the employee.

In spite of the distances involved, it seems evident that most corporations do not, at least for the present, see the benefits to decentralizing the payroll function. There is some indication that a regionalization of at least a portion of the payroll function may be beneficial to the staying in touch function.

One payroll manager made the statement that their particular system had been subjected to patches for so many years that it was time to start from the ground up and design an automated system that is representative of today's state-of-the-art. It is also thought important in the redesign of a system to involve the data processing group within a corporation. Thus, Mariott Corporation is working on the redesign of their system with data processing, payroll and an outside consulting CPA firm.

Of major concern to many corporate groups is the control and security of the payroll system. There is some reluctance on the part of corporate headquarters to consider totally decentralizing the function since they have not come to an agreement on how to protect the information within a payroll system and protect its access from someone with criminal intent.

The protection of the system security is likely the greatest argument for regionalizing only a portion of the system. Further, the corporate accounting function is in headquarters and the payroll expense and management is centralized within this group. As a result, tax reporting information eminates from this area and there is some economy of scale in centralization.

2. Tax and Record Keeping Incentives

The most often mentioned reason for automating payroll is the benefits which could accrue from precise record keeping. Not only are corporations swamped with reporting requirements by government agencies, local state and Federal, but there are benefits to reducing the problems associated with "proving" expenses and deductions are legitimate.

Targetting Jobs programs, earned income credits, and youth employment require precise record keeping for the corporation to take the deductions and accrue the benefits associated with the programs. The IRS could audit these types of programs and therefore, private industry does not want to incur needless time in tax audits over and above what is presently required.

These programs, it should be mentioned, also offer tax benefits to corporations, or other types of savings. For example, the employment of teenagers on a part-time basis saves a corporation the cost of providing paid benefits and vacations. Thus, a company such as McDonalds does not offer benefits to any other than full-time personnel. However, employing teenagers exposes McDonalds to various types of child labor laws. There are, of course, sufficient trade-offs to make this worthwhile.

COMPARISON OF PAYROLL PROCEDURES
UTILIZED BY COMMERCIAL/INDUSTRIAL ORGANIZATIONS

Procedure/Function	ORGANIZATION			
	TWA	General Mills	Ringling Bros. Circus	McLean Trucking
Centralized Payroll System	x	Partial	x	x
Mail-based system		x		
Check distribution by:				
o U.S. Mail	x		?	
o Federal Express		x		
o Combination				
oOther means			Air Frt.	
Input from field:				
o U.S. mail		x		
o CRT or other terminal	x?			x
o Other means				
Computer System:				
o Tape based		-		x
o Disk based	x	-	x	x
EFT used for payroll	-			
Override capability in the field	-	x	x	
Payment made by:				
o Check	x	x	x	x
o Cash			x	
o Combination			x	
Payroll/Personnel Files Combined	x	x	x	x
System redesign in progress				
Checks printed:				
o Central payroll	x	x	x	
o Field unit or region				

COMPARISON OF PAYROLL PROCEDURES
UTILIZED BY COMMERCIAL/INDUSTRIAL ORGANIZATIONS

Procedure/Function	ORGANIZATION			
	McDonald's	Marriott	Texaco	Control Data
Centralized Payroll System	x	x	x	x
Mail-based system		x	x	
Check distribution by:				
o U.S. Mail		x	x	x
o Federal Express		x		x
o Combination				
oOther means	Courier			
Input from field:				
o U.S. mail		x	x	
o CRT or other terminal	x			
o Other means				x
Computer System:				
o Tape based	?	x	x	?
o Disk based			x	
EFT used for payroll				
Override capability in the field			x	
Payment made by:				
o Check	x	x	x	x
o Cash				
o Combination				
Payroll/Personnel Files Combined	x		x	x
System redesign in progress		x		
Checks printed:				
o Central payroll		x	x	x
o Field unit or region	x		x	

COMPARISON OF PAYROLL PROCEDURES
UTILIZED BY COMMERCIAL/INDUSTRIAL ORGANIZATIONS

Procedure/Function	ORGANIZATION: Seaboard Coastline	Roadway Express	American Pres. Lines	Smith Transfer
Centralized Payroll System	x	x	x	x
Mail-based system			?	Trucks
Check distribution by:				
o U.S. Mail	?			
o Federal Express				
o Combination		x		
oOther means		Trucks	Courier	Trucks
Input from field:				
o U.S. mail	x		?	Trucks
o CRT or other terminal	x	x		
o Other means				
Computer System:				
o Tape based	x			
o Disk based			x	x
EFT used for payroll				
Override capability in the field		x		
Payment made by:				
o Check	x	x	x	x
o Cash			x	
o Combination				
Payroll/Personnel Files Combined	x	x	x	
System redesign in progress				
Checks printed:				
o Central payroll	x	x	x	x
o Field unit or region				

COMPARISON OF PAYROLL PROCEDURES
UTILIZED BY COMMERCIAL/INDUSTRIAL ORGANIZATIONS

	ORGANIZATION			
Procedure/Function	Greyhound	Bechtel		
Centralized Payroll System	Two regions	Partial		
Mail-based system	x	x		
Check distribution by:				
o U.S. Mail	x	x		
o Federal Express				
o Combination				
oOther means	Busses			
Input from field:				
o U.S. mail	x	x		
o CRT or other terminal				
o Other means		x		
Computer System:				
o Tape based	x	x		
o Disk based				
EFT used for payroll				
Override capability in the field	x			
Payment made by:				
o Check	x	x		
o Cash				
o Combination				
Payroll/Personnel Files Combined				
System redesign in progress		x		
Checks printed:				
o Central payroll	x	x		
o Field unit or region		x